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A Survey of Parasites of the Larch Sawfly (*Pristiphora erichsonii* (Hartig)) in Manitoba and Saskatchewan[1]

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Introduction

Records indicate that the present outbreak of the larch sawfly in Manitoba and Saskatchewan began about 1938 in the Spruce Woods-Riding Mountain area of Manitoba. Since then, it has spread in all directions where the principal host tree, larch, *Larix laricina* (Du Roi) K. Koch, occurs. It now includes nearly all of Manitoba and Saskatchewan, northwestern Ontario, part of northeastern Alberta, and northern Minnesota. In 1944, an annual survey of parasites that attack larvae of the larch sawfly was begun by the Forest Biology Laboratory, Winnipeg. The purposes of the survey were to determine (a) the principal species of parasites, (b) their abundance and effectiveness, and (c) host-parasite population trends.

Methods

The insect overwinters as a last-instar larva in a cocoon in the soil; all the main parasites may be found in this stage of the host. Larch sawfly cocoons were collected in the field in the autumn and the larvae in them were dissected or reared during the winter. A number of collection points were selected to represent infested areas. As the outbreak spread, new collection points were added. At the peak of the survey in 1951, 85 locations were sampled in Manitoba and Saskatchewan.

After collection, cocoons were packed in moss in small screen cages or standard Forest Insect Survey collecting tins and shipped to Winnipeg for storage. They were stored in a cool root cellar at about 40°F. during the early years of the survey, and in a cold room at 34°F. since 1950. During the winter, at least 100 larvae from each sampling point were dissected. Another lot of 100 or more cocoons from each area was reared to determine the species of parasites present. In this paper, data on parasite abundance are based on larval dissections, as efforts to rear adults from cocoons were only moderately successful.

Results

This survey shows that the parasite complex in the Prairie Region consists of three principal species; *Bessa harveyi* (T.T.) (Tachinidae), *Mesoleius tenthredinis* Morley (Ichneumonidae), and *Tritneptis klugii* (Ratz.) (Pteromalidae). Infrequently individuals of the following species were reared from cocoons:

Hymenoptera

Aptesis indistincta (Prov.)
Dusona sp.
Macrocentrus uniformis Prov.
Perilampus sp.
Euceros thoracicus Cress.
Eclytus ornatus Holmg.
Ctenochira sp.

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TABLE I
Defoliation History at Parasite Sampling Points in Manitoba and Saskatchewan[1]

Year	Manitoba							Saskatchewan			
	Whiteshell For. Res.	Seddon's Corner	Sandilands For. Res.	Riverton	Norgate Rd., Riding Mt.	Dauphin Rd., Riding Mt.	Renwer	Pelly	Hudson Bay	Prince Albert	Meadow Lake
1940					L	L					
1941				H	L-M	L					
1942				H	H	L					
1943				M-H	H	L					
1944				M-H	H	L					
1945	L-M	L	L-M	M	M-H	M	M	H	L	Nil	Nil
1946	M	M	M	L-M	M	M-H	H	H	L	Nil	Nil
1947	M-H	H	M	L	M-H	H	H	M	M	L	Nil
1948	H	H	H	L	M	M	M	M	M	H	L
1949	M-H	M-H	M-H	L	L	L	L	M	M-H	H	L
1950	H	M	L-M	M-H	M	L	M	M	H	H	L
1951	H	L-M	L-M	H	M	L	H	L-M	H	H	L
1952	H	M-H	L-M	L	L	L	L-M	L	M-H	M	L
1953	L-M	L	M-H	L	L	L	L	L	L	M-H	M

1. L = light, M = moderate, H = heavy.

Diptera

Megaselia sp. *Fannia* sp.
(questionable parasite)

Table 1 shows the defoliation history of larch in a number of representative stands for which parasitism by *B. harveyi* and *M. tenthredinis* is reported in succeeding sections. These are ocular estimates, which leave much to be desired, but they provide a rough indication of the development of the infestation, peak years of defoliation, and subsequent declines where they have occurred. Locations are listed from east to west. It is unfortunate that owing to staff shortages, no defoliation estimates are available for most areas prior to 1945.

Results relating to the principal species mentioned above are presented in separate sections below.

BESSA HARVEYI (T.T.)

The origin of this species in North America is obscure (Hawbolt, 1947). It may be native or introduced. The adult parasites lay macrotype eggs supracutaneously on late-stage sawfly larvae in the field. Most parasites overwinter as partly developed maggots in the host, though a number, sometimes as high as 25 per cent, may emerge from their hosts in late summer and form puparia in the ground (Muldrew, 1953a). Therefore the true parasitism, based on cocoon dissections, is underestimated. However, data obtained from this survey are indicative of parasite population trends. Furthermore, the elaborate sampling procedures required to obtain a complete picture of parasitism could not be undertaken in an extensive survey of this nature.

Table 2 lists the percentage of larch sawfly larvae in cocoons parasitized by *B. harveyi*. Areas sampled are the same as those shown in Table 1.

Table 2 exhibits several interesting trends. In the early stages of an infestation, populations of *B. harveyi* appear to build up slowly, reaching a maximum per cent parasitism five to eight years after initial recovery from the area. The per cent parasitism usually reaches a maximum three to five years after the infestation has reached its peak. Then the per cent parasitism remains fairly high, even in the declining phases of an infestation. At several points in Manitoba, (the Whiteshell Forest Reserve, Seddon's Corner, Sandilands Forest Reserve, Riverton, and Norgate Road), parasitism reached high levels during the peak years of the outbreak and must have been an important factor contributing to the decline of the larch sawfly in these areas.

Parasitism by *B. harveyi* has been relatively low in two areas during most of the outbreak, at the Dauphin Road in Riding Mountain, and Prince Albert. This is especially striking at the Dauphin Road site when compared to the high parasitism at Norgate Road, 13 miles away. It is possible that abundance of *B. harveyi* may be limited by certain faunal or floral characteristics of the local habitat, but this has not been investigated. It is too early to anticipate trends at Meadow Lake. It is perhaps noteworthy that parasitism by *B. harveyi* never exceeded 60 per cent of the cocooned larvae in the areas sampled. Several characteristics mentioned by Hawbolt (1947) may account for the inability of the parasite to attack a greater proportion of the host population.

MESOLEIUS TENTHREDINIS Morley

The history of this introduced parasite in the Prairie Region is described in a recent paper (Muldrew, 1953b). It increased rapidly following introduction,

TABLE II
Percentage of Sawfly Larvae in Cocoons Parasitised by *B. harveyi*

Year	Manitoba							Saskatchewan			
	Whiteshell For. Res.	Seddon's Corner	Sandilands For. Res.	Riverton	Norgate Rd., Riding Mt.	Dauphin Rd., Riding Mt.	Renwer	Pelly	Hudson Bay	Prince Albert	Meadow Lake
1944	—	—	—	2	4	—	—	—	—	—	—
1945	—	—	—	17	17	0.3	—	—	—	—	—
1946	0	0	—	21	6	0	0	—	—	—	—
1947	6	7	3	32	27	2	0	0	2	—	—
1948	—	10	1	32	48	7	1	2	2	2	—
1949	9	15	13	18	41	0	7	10	2	1	—
1950	24	33	15	46	34	2	8	14	0	0	—
1951	45	44	25	30	35	5	16	22	22	3	0
1952	19	54	29	28	28	23	25	13	37	2	0
1953	16	59	11	11	11	22	26	19	16	6	1

but during the present outbreak, it has proved disappointing, rarely killing more than 5 per cent of the host population. The reason for this decreased effectiveness is that the host population has developed an immunity to the parasite (Muldrew, 1953b). The importance of this reaction in restricting the effective parasitism during the current outbreak is clearly indicated in Table 3. It shows data on parasitism by *M. tenthredinis* accumulated from the same areas listed in Tables 1 and 2. Percentages are based on at least 100 dissected larvae per sample. "Total parasitism" refers to host larvae containing parasite eggs or larvae of *M. tenthredinis*, and "Effective parasitism" refers to host larvae containing larvae of *M. tenthredinis*. The difference between the two represents the proportion of host insects in which the immunity reaction prevented parasitic development.

Table 3 shows that though the number of larvae parasitized by *M. tenthredinis* is sometimes high, occasionally exceeding 50 per cent, the number of parasite eggs that hatch is usually very low. That the parasite is able to survive in the face of the immunity factor is remarkable. This is indicative of its high biotic potential and searching ability, and it is not surprising that it is an efficient control agent in regions such as British Columbia, where the immunity factor is practically inoperative.

Two interesting conclusions are suggested by Table 3, (a) that the incidence of the immunity reaction varies greatly from year to year and between areas, and (b) there is no discernible trend in the proportion of the host population exhibiting the reaction. Nothing is known of the influence of genetic factors on the reaction. Any approach to this problem is complicated by the fact that the host insect is partly, or possibly completely, parthenogenetic. There is some evidence that environmental factors may be responsible for the occasional breakdown of the resistance mechanism. For example, Muldrew (1952) found that when parasitised larvae were reared at various temperatures (i.e. 48°F. to 85°F.) the highest percentage of parasite eggs hatched at the lowest temperature. He also found that a greater proportion of parasite eggs hatched in unhealthy host larvae.

The immunity appears to have developed rapidly in the host populations in the Prairie Provinces. In 1927, effective parasitism of cocoons in some parts of the Spruce Woods Forest Reserve, Manitoba, was reported as high as 88% (Criddle, 1928). By 1940, when the present outbreak began to develop, the immunity appeared to be well established in the host population. It is suspected that larch sawfly populations in the outbreak area of central Canada and Minnesota possesses varying degrees of resistance to *M. tenthredinis*. A recent report (Drooz, 1953) states that the immunity reaction is present in Minnesota sawfly populations.

The results of this survey, and recent work by Muldrew (1953b), suggest that *M. tenthredinis* cannot be expected to play a prominent part in the control of the larch sawfly in the Prairie Provinces under present conditions.

TRITNEPTIS KLUGII (Ratz.)

This species is reported by Hewitt (1912) as native to North America. Prior to the present outbreak, the last recorded year of recovery was in 1927, in the Spruce Woods Forest Reserve, Manitoba.*

T. klugii attacks the cocoon stage of the larch sawfly and completes development therein. Evidently development continues as long as suitable temperatures prevail (Hewitt, 1912); there is probably more than one generation per year.

*Personal communication—Dr. A. Wilkes, Belleville, Ontario, November 27, 1950.

TABLE III
Total and Effective Per Cent Parasitism by *M. tenthredinis* as Determined by Larval Dissections

Year	Manitoba														Saskatchewan							
	Whiteshell For. Res.		Seddon's Corner		Sandilands For. Res.		Riverton		Norgate Rd., Riding Mt.		Dauphin Rd., Riding Mt.		Renwer		Pelly		Hudson Bay		Prince Albert		Meadow Lake	
	T*	E**	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E	T	E
1944									0	0												
1945							12	2	13	1	14	2										
1946			9	1			12	3	12	1	8	1	2	0								
1947	3	1	2	1	1	0	11	3	11	1	9	2	3	1	32	9	3	1				
1948	—	—	5	0	7	3	1	0	17	2	52	2	18	4	52	4	23	3	23	2		
1949	7	4	1	1	4	3	2	2	5	3	11	3	20	7	11	0	1	0.5	52	14		
1950	10	1	1	0	0	0	1	0	6	2	2	0	6	5	13	1	6	4	47	19		
1951	12	1	0	0	3	2	1	1	4	3	8	3	17	6	4	0	13	4	46	6	0	0
1952	24	7	4	0	0	0	3	1	23	3	4	2	18	6	1	0	3	1	40	21	8	4
1953	8	4	1	0	1	1	1	0	6	2	0	0	13	5	11	9	0	0	48	14	30	6

*Total parasitism.
**Effective parasitism.

TABLE IV
Per Cent Parasitism of Larch Sawfly Cocoons by *T. klugii*

Year*	Area	Per cent parasitism
1939	Spruce Woods For. Res., Man.	0.2
1941	Spruce Woods For. Res., Man.	7.5
1942	Riding Mt., Man.	1.5
1949	Crutwell, Sask.	1.2
	Fort a la Corne, Sask.	0.4
1950	Crutwell, Sask.	0.0
	Fort a la Corne, Sask.	16.7
	Nisbet Forest, Sask.	23.4
	Mayview, Sask.	3.0
	Canwood, Sask.	1.0
1951	Channing, Man.	4.0
	Cranberry Portage, Man.	27.5
	Amisk Lake, Sask.	1.0
	Chemong, Sask.	1.2
	Wachee, Sask.	1.2
	Ruby Lake, Sask.	5.5
	Veillardville, Sask.	5.6
	Hudson Bay, Sask.	2.4
	Nisbet Forest, Sask.	3.5
	Big River, Sask.	1.0
1952	Crutwell, Sask.	1.2
	Veillardville, Sask.	1.0
	Armit Rd., Sask.	1.1
1953	Montreal Lake, Sask.	2.0
	Wachee, Sask.	1.0
	Snowden, Sask.	1.0

T. klugii was not recovered from cocoons collected during 1943 to 1948 inclusive.

Table 4 shows the areas from which *T. klugii* was recovered during the present outbreak. Per cent parasitism is based on dissection of at least 100 cocoons per sample. In the collections showing parasitism of 16.7, 23.4, and 27.5 per cent, it is possible that larch sawfly material was contaminated during storage by parasites emerging in the sample.

It is suspected that it is difficult for *T. klugii* to survive periods of low host density. The adult parasite is a small insect that finds its host by searching the soil for cocoons, and cocoons, when scarce, cannot be found easily. This hypothesis might offer a partial explanation for the absence of *T. klugii* from cocoon samples over nearly the entire outbreak area until 1949. With few exceptions, recoveries indicate a low degree of parasitism and sporadic occurrence of the parasite.

In an attempt to re-establish the species, a program of liberations was initiated in 1948 with the co-operation of the Insect Parasite Laboratory, Belleville, Ontario. Colonies of parasites were released in 1948, 1949, and 1952 as indicated in Table 5.

Though it may be too early to evaluate the success of these liberations, an examination of Table 4 indicates that results to date are not encouraging. Crutwell, Saskatchewan, is the only liberation point from which *T. klugii* was recovered. In the other areas listed in Table 4, the parasite appeared in the host

TABLE V
Releases of *T. klugii* in Manitoba and Saskatchewan

Date	Number released	Location
July 6/48	1,400	0.6 miles N. of Seddon's Corner, Man. Sec. 3, tp. 13, rge. 9, E.P. mer.
July 26/49	823	Whiteshell Forest Reserve, Man. Sec. 17, tp. 12, rge. 15, E.P. mer.
Aug. 24/49	9,116	" " " "
Aug. 2/49	12,713	Renwer, Man., mi. 251 Hwy. 10, Sec. 18, tp. 36, rge. 23, W.P. mer.
Aug. 13/49	3,743	" " " "
Aug. 31/49	9,900	" " " "
Aug. 7/49	12,850	Crutwell, Sask., sec. 22, tp. 49, rge. 1, W. 3rd mer.
Aug. 11/52	4,685	" " " "

populations without benefit of liberations. Nevertheless, some success might be achieved by attempting to re-establish *T. klugii* in the early stages of an outbreak, but further work is necessary in the study of its general biology and habits to obtain a better understanding of its limitations and potentialities.

Discussion

A scarcity of species characterizes the larch sawfly parasite complex in the Prairie Provinces. *B. harveyi* is the only one that appears to exert any appreciable measure of control. *M. tenthredinis* now contributes little because of the immunity reaction in the host population, and *T. klugii* appears sporadically and unpredictably. Few forest insects have such a meagre complement of major parasites.

It is not implied that other important biological control factors are lacking. Insect predators destroy a portion of the host population, but their controlling influence is not considered substantial. Birds undoubtedly destroy some of the larch sawfly population. Mice and shrews frequently destroy more sawflies than any other biological control factor, (Buckner, 1953). However, mortality caused by small mammals and birds is evidently not very sensitive to host-density changes, and is therefore variable. Disease organisms cause some mortality, but no virulent organisms have been found attacking the larch sawfly.

Further mention should be made of the immunity to *M. tenthredinis* exhibited by the larch sawfly in Manitoba and Saskatchewan, since this appears to be an important factor in the population ecology of the insect. In these two provinces, where the immunity reaction has practically nullified the control exerted by *M. tenthredinis*, larch sawfly infestations appear to be very persistent. For example, after 15 years of attack many stands in Riding Mountain Park, Manitoba, still contain larch sawfly populations of sufficient density to cause noticeable defoliation. On the other hand, circumstantial evidence indicates that in British Columbia, where the immunity reaction is almost absent, *M. tenthredinis* has played a prominent role in the recent virtual disappearance of the larch sawfly from infested areas. Though not specifically supported by data presented in

this paper, the hypothesis is advanced that the present outbreak in central Canada and Minnesota is caused by a strain of larch sawfly resistant to *M. tenthredinis*, which has spread out from an area or point of origin probably located in Manitoba. It is proposed to test this hypothesis. If proved correct, important implications regarding future abundance and control of the larch sawfly follow as a natural consequence.

The situation revealed by this survey and related studies indicates that the present complement of control factors in the Prairie Provinces does not provide adequate economic control of the larch sawfly. The existing parasites, predators, and diseases may reduce sawfly populations to sub-infestation levels under suitable conditions. But they do not appear capable of lowering populations to the point where reasonably long periods free from sawfly outbreaks can be expected. The addition to the complex of even one highly sensitive density-dependent factor, such as a virulent disease, or an efficient parasite or predator, could greatly improve control prospects.

Acknowledgments

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A New Genus and Species of Aphidae (Homoptera) on *Philadelphus* sp.[1]

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An aphid collected on *Philadelphus gordonianus* Lindl. at Agassiz, British Columbia, by R. Glendenning was sent to the writer for identification. The specimens could not be determined and extensive examination indicated that a new genus and species of aphid were involved.

Glendenningia new genus

Alate Parthenogenetic Female.—Body irregularly elongate-oval. Head without prominent frontal tubercles; antennae six-segmented, with circular, rimmed sensoria. Wing venation normal: fore wings with media twice-branched, hind wings with media and cubitus present. Cornicles swollen, longer than the cauda. Cauda mammiform, with a drawn-out, conical tip.

According to Baker (1920) the genus falls in the subfamily Aphidinae, tribe Aphidini. According to Palmer (1952) it falls in the subfamily Aphinae, tribe Aphini. The genus resembles *Liosomaphis* Walker as discussed by Baker (1920) and *Rhopalosiphum* Koch as discussed by Baker (1920) and Palmer (1952). It differs from *Liosomaphis* in having the cornicles less abruptly swollen, and from *Rhopalosiphum* in having the cornicles more swollen. The form of the cauda distinguishes it from other genera in the subtribe Aphina that have swollen cornicles. *Aphis rosea* (Baker) has a cauda of similar form.

Type species: *Glendenningia philadelphi* n. sp.

Glendenningia philadelphi n. sp.

Fig. 1

Alate Parthenogenetic Female (Colour notes from mounted specimens).—Head and thorax dark brown to black; antennae dusky; femora black except basal extremities, which are paler; tibiae and tarsi dark with distal ends darker than remaining portions; femora darker than tibiae; tibiae darker than tarsi. Wing veins dark. Abdomen lighter than the head and thorax, with a large dark dorsal patch and dark lateral spots. Dorsal patch irregularly diffused marginally, and with darker segmental bars and dashes. Cornicles and cauda dark.

Medium-sized, body length 2.24 to 2.80 mm. (average 2.62 mm.). Antenna, 2.10 mm.; I, 0.08 mm.; II, 0.08 mm.; III, 0.64 to 0.70 mm. (average 0.67 mm.); IV, 0.33 to 0.41 mm. (average 0.38 mm.); V, 0.25 to 0.36 mm. (average 0.29 mm.); VI, base 0.12 to 0.16 mm. (average 0.14 mm.); flagellum, 0.35 to 0.51 mm. (average 0.445 mm.). Head width through eyes, 0.56 to 0.60 mm. (average 0.56 mm.). Hind tibia, 1.40 to 1.60 mm. (average 1.50 mm.). Cornicle, 0.68 to 0.75 mm. (average 0.71 mm.). Cauda, 0.10 to 0.16 mm. (average 0.145 mm.).

Secondary sensoria circular, with narrow rims, scattered over entire surface of segments III and IV and in a more or less straight line on V. Sensoria variable in number between specimens and on opposite sides of the same specimen; 47 to 61 (average 53) on III; 17 to 28 (average 22) on IV; 3 to 11 (average 7) on V. Cornicles swollen in apical half and enlarged basally, with a slightly constricted area between; the swollen apical portion constricted before the flange. Cornicle

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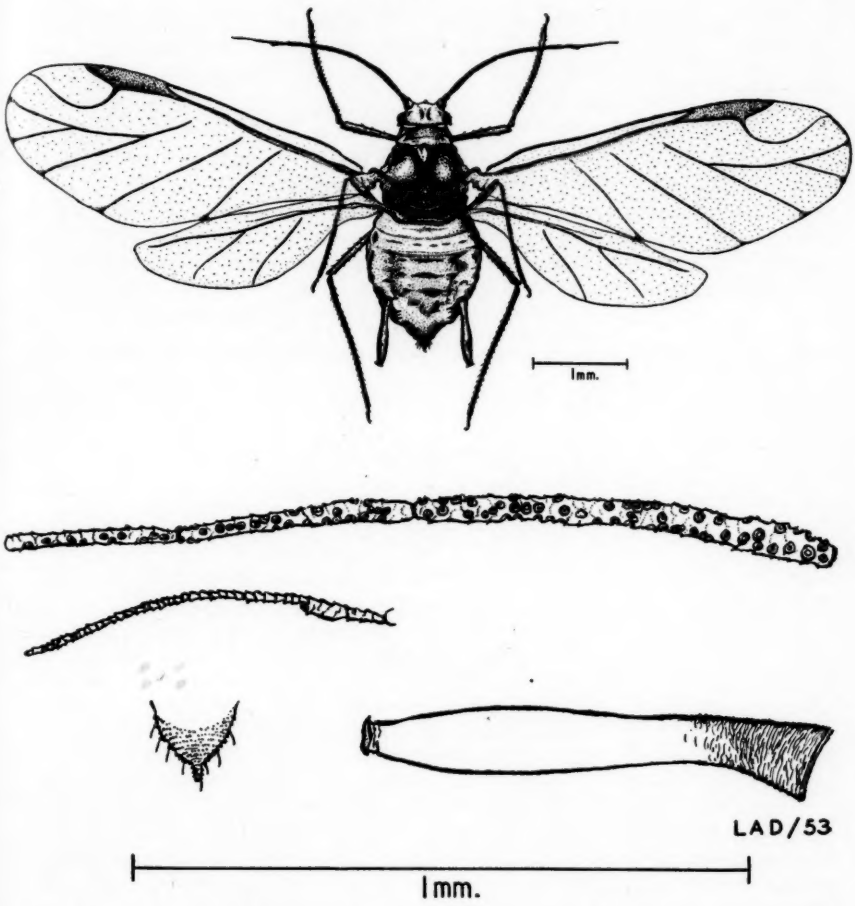

Fig. 1. *Glendenningia philadelphi*, n. sp. Alate parthenogenetic female with antenna, cauda, and cornicle enlarged.

transversely wrinkled at base; two or three striae surrounding apex, close to the flange; surface of cornicle slightly scarious. Cauda mammiform, with a swollen basal portion and a drawn-out, conical tip; three pairs of lateral hairs on the swollen portion and one or two dorsal hairs on the drawn-out tip. Spiracular openings prominent; hairs on body and appendages pointed, short, and sparse. Rostrum approaching or reaching second coxae.

Food Plant.—This aphid was collected from *Philadelphus gordonianus* Lindl. on June 22, 1951. Only alate parthenogenetic females and nymphs bearing wing pads were present. Collections from the same shrub in 1952 yielded no aphids.

Distribution.—Known from Agassiz, British Columbia.

Holotype.—Alate viviparous female, Agassiz, British Columbia, June 22, 1951 (R. Glendenning), on *Philadelphus gordonianus* Lindl.; No. 6114 in the Canadian National Collection, Ottawa.

Paratypes.—Twenty-four alate viviparous females, Agassiz, British Columbia, June 22, 1951 (R. Glendenning), on *Philadelphus gordonianus* Lindl.; in the Canadian National Collection, Ottawa, at the Fredericton laboratory, and in the collection of E. O. Essig, University of California.

The genus is named after R. Glendenning, formerly Officer-in-Charge, Entomology Laboratory, Agassiz, B.C. In the early years of his career, Mr. Glendenning pioneered the study of aphids in British Columbia.

Acknowledgment is made to Mr. L. A. Dionne, Fredericton laboratory, for preparing the drawings; and to Professor E. O. Essig, University of California, for examining the specimens, confirming the author's belief that they were new to science, and reviewing the manuscript.

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The Nymph of *Rhithrogena impersonata* (Ephemerida) and a New Closely Related Species from the Same Locality in Southern Ontario

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Early in the summer of 1951 a small collection of aquatic insects was submitted to the author by J. Goodwin of Toronto, taken from Sheldon Creek in Dufferin County, Ontario. Included were nymphs of two readily distinguishable species of Rithrogena, one having bright red gills and the other hyaline whitish gills. Those with hyaline whitish gills were more abundant and proved to be *R. impersonata* Mc.D. of which specimens from Baddeck, N.S. and Lachine, P.Q. are in the Canadian National Collection at Ottawa. I have records of this species in both nymphal and adult stages from the Credit River, Peel County, Ontario, where the association of nymph and adult was made, and in the nymphal stage from the Saugeen River in Grey County, Ontario. The nymphs with red gills proved to be those of a new species which, considering genitalic characters, is closely related to *R. impersonata.*

In 1952 several visits were made to the locality in the expectation of finding the subimagos emerging and the adults swarming. Adults were found swarming on June 1, 2, and 5, and on the last two visits the swarming was observed to extend from approximately 8-9.15 p.m. E.D.T. and was particularly noticed over a bridge spanning the river. The swarm was rather compact with little undulation of the individuals composing it and only occasionally dropping down to a level which made capture possible. A few individuals were observed emerging as subimagos from the rapids at 6.45 p.m. E.D.T. on the 2nd. Adults of both species were taken in the swarm on all occasions and the nymphs of both were found in the same location in the rapids, frequently intermingling on the same stones. The

ratio of adults in the swarm was approximately 40 of *R. impersonata* to 6 of the new species and the nymphs were present in about the same proportion.

In 1953 the locality was visited on June 14th, 18th, 19th, and 21st during the evening at the time of swarming. The swarming interval varied and on June 21st, a warm day, began at 8.55 p.m. E.D.T. and ended at 9.40 p.m. The collecting on these latter occasions was directed towards obtaining mating pairs of the two species of Rhithrogena which could be discerned briefly associated as they left the swarm. Two of the apparent pairs thus taken were a male *R. impersonata* with a female *Ephemerella excrucians* Walsh and a male *R. impersonata* with a female *Siphlonurus rapidus* Mc. Dunnough. The remaining thirteen pairs obtained were in all cases a male with a female of the same species, twelve pairs of *R. impersonata* and one of the new species.

***Rhithrogena impersonata*, McD.**

Nymph: length 7 mm., caudal filaments 9 mm.

Head: subovate, wider than long; umber brown of variable intensity including pale mid-dorsal line on vertex, narrow pale area from front of eye to lateral border, pale line between lateral ocelli and passing anterior to eye. Antennae basally umber brown paling to whitish apically.

Thorax and wing pads: umber brown with pale median line. Femora with conspicuous pattern as shown in figure 7.

Abdomen: dorsally unicolorous umber brown, ventrally umber with darker pattern in the form of a pair of segmentally arranged submedian dark dots, anterior border of segments with dark laterally directed patches, lateral borders pale. In some individuals the venter is uniformly dark, in others almost unpigmented. Gills whitish hyline with distinct but not blackish venation, gills of segment 1 convergent apically, with scalloped anterior border, folded and fused to or at least adhering to the venter by its dorsal surface (Fig. 5). Intermediate gills with median ear-like lobe. Caudal filaments dark brown basally, paler apically with distinct joints.

This species is dark unicolorous umber brown with conspicuous pattern on the femora, clear whitish hyline gills with small median lobe as described for *R. doddsi* Mc. D.

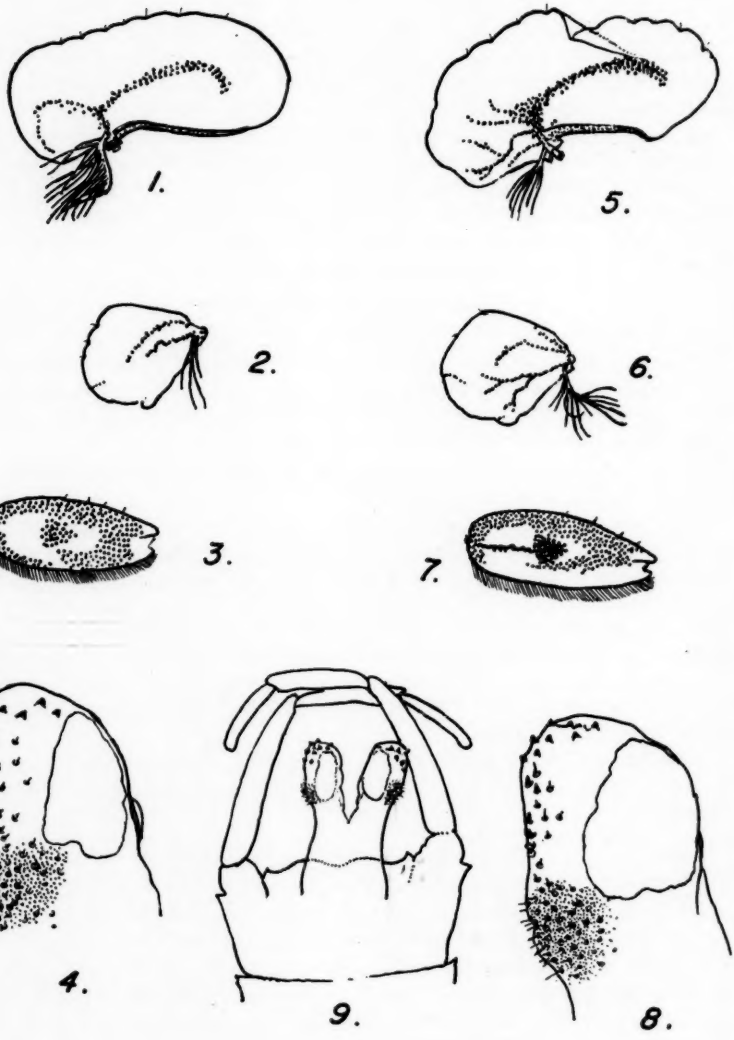
***Rhithrogena sanguinea*, new species**

Male imago (dried): length 8 mm., caudal filaments 17 mm., forewing 10 mm.

Head: eyes and area between ocelli dark brown tinged with purple; frons ochre yellow with red flush near eyes and at tip; antennae brown, paler apically.

Thorax: dorsum reddish brown with ruddy area anterior to scutellum, pale and yellowish laterally with distinctly ruddy area anterior to wing base and around base of meso- and metathoracic legs; femora red-brown, darker brown at the apex and yellowish at extreme base; scarcely discernible dark stroke basad of the middle; fore tibia smoky with dark brown apex, remaining tibiae brown basally; wings hyaline, slightly brownish-grey basally in some lights, venation brown.

Abdomen: dorsum dark brown, narrowly hyaline on anterior borders, posterior borders of anterior segments narrowly reddish, segments 8, 9 and 10 opaque and paler; venter smoky, opaque and buff-coloured on segments 8 and 9, faint markings in form of oblique stroke across antero-lateral angle and small submedian dark spots; forceps base ochre yellow, remainder smoky; caudal filaments with basal curvature characteristic of the group, dark smoky with segments indistinctly separated by darker lines; genitalia (Figs. 4 and 9) of the



1-3 *Rhithrogena sanguinea* n. sp., (1) gill 1, left, dorsal view, (2) gill 2, left, dorsal view, (3) femur of front right leg.

4 *R. sanguinea*, right penis lobe, dorsal view.

5-7 *Rhithrogena impersonata* Mc.D., (5) gill 1, left, dorsal view, (6) gill 2, left, dorsal view, (7) femur of front right leg.

8 *R. impersonata* Mc.D., right penis lobe, dorsal view.

9 *R. sanguinea*, male genitalia, dorsal view.

R. impersonata form lacking a basal spine on the penis lobe and with sparse short spines apically.

Female imago (dried): length 7 mm., caudal filaments 12 mm., forewing 10 mm.

Head: eyes grey; vertex and interocellar area umber brown; frons dark red ventrally, yellow patch medially and others ventral to lateral ocelli, bright red laterally extending dorsally along margin of eye; antennae brown, paler apically.

Thorax: dorsum brown, pale yellowish at sides in front and at base of wings; red on pleura in front of and ventral to wing bases; scutellum with pale areas; coxae yellowish with red patch; trochanters yellow basally, red distally; femora reddish brown, narrowly yellowish basally; tibiae paler reddish brown and tarsi piceous; wings hyaline with brown venation.

Abdomen: terga dark brown, venter paler; intersegmental folds reddish; caudal filaments pale basally, remainder piceous with darkened joints, no abrupt bending ventrad.

Female subimago, (dried): length 8 mm. caudal filaments 7 mm. wing 10 mm.

In this single individual the frons and the areas on the thorax which were reddish in the imago male are also reddish though somewhat duller; wings grey becoming paler greyish-yellow at tips and along posterior border of hind-wings; dark strokes of central area of femur scarcely discernible but apices of femora slightly darkened; caudal filaments smoky with indistinct joints.

Nymph (alcohol): length 7 mm., caudal filaments 9 mm.

Head: subovate and wider than long, reddish brown with pale area postero-laterad of eye, a pale streak extending in front of eye to lateral border, a faint median dark line on frons, red patch laterad of lateral ocellus; antenna brown, paler apically. In males the distance between the compound eyes is less than the diameter of an eye and in females greater.

Thorax: pale brown with paler mid-dorsal line, irregular patches at base of wing pads; femora pale basally, indistinct spot centrally and darker maculation extending to near apex as shown in Fig. 3; in most individuals femora entirely suffused with bright red.

Abdomen: dorsally reddish brown darker and more ruddy on posterior borders, ventrally without conspicuous marking, pale or with pale reddish brown suffusion intensifying posteriorly; gills bright carmine red (blood red in life) medially becoming paler and colourless laterally, gills of segments 1 and 7 convergent but gill 1 not folded, tracheae indistinct, small median lobe on intermediate gills as in *R. doddsi* and *R. impersonata*, tuft of gill filaments on gill 1 with about twelve filaments, that on gill 2 with 5 or 6 (Figs. 1 and 2); caudal filaments pale with darker brown base.

This nymph is pale reddish brown with carmine red gills and with median lobe on those of intermediate segments. The pattern on the femora, particularly the central spot, is relatively inconspicuous,

Holotype, male: Sheldon Creek, Dufferin County, Ontario, June 5, 1952. F. P. Ide.

Allotype, female: Sheldon Creek, Dufferin County, Ontario, June 17, 1953. F. P. Ide.

Paratypes: 5 male imagos, 1 female subimago. Sheldon Creek, Dufferin County, Ontario, June 1-5, 1952. F. P. Ide.

In living material of *R. sanguinea* some additional features are apparent. The eyes of the male imago are brown, the femora are flushed with bright red which is particularly intense along the borders, the central dark dash of the femora is obsolescent or wanting, the bases of the tibiae are greenish. The thorax

and abdomen are suffused with red pigment which is particularly conspicuous on the intersegmental folds of the abdomen. The maculation of the abdomen is variegated with pale geminate spots near the middle line in the posterior half, pale paramedial strokes in front of these converging on the middle line anteriorly; laterally, at the front, are two dark strokes separated from one another and from the lateral border by pale areas. The lateral flanges are reddish.

Living individuals of *R. impersonata* have a decidedly greenish tinge which is most noticeable in the areas which are red in *R. sanguinea* but this is lost in the dried specimens and probably also in specimens in alcohol. It seems probable that the red pigment of one species and the green of the other are related biochemical substances. It is possible that they have some significance in respiration. The distribution of the two pigments in a similar manner in parts of the body having thinner cuticle and the fact that the pigment carries through from the nymph and subimago to the imago suggests that it is a blood or muscle pigment rather than part of the external colour pattern.

R. impersonata and *R. sanguinea* can be readily separated from all other described species of Rhithrogena in the adult stage on characters of the genitalia. *R. jejuna* Eat. which has a wide distribution with records from Lachine on the St. Lawrence and Cascades on the Gatineau River in the Province of Quebec, from Smoky Falls on the Kapuskasing River in Northern Ontario, from Churchill on the Churchill River in Manitoba and from localities further west in Canada can be readily distinguished on genitalic characters from these two species, Needham et at (9). From *R. rubicunda* Traver, a species with ruddy colour, and from *R. amica* Traver they can be readily distinguished on genitalic characters as they lack the spatulate process on the penis, Traver (12). No satisfactory character, however, has been found in the genitalia for separating *R. sanguinea* from *R. impersonata.* There are more setae in the central part of the penis lobe in the one than in the other as shown in Figs. 4 and 8 but the difference in the figures is exaggerated owing to the slightly different aspects shown in the two cases. The two species can, however, be readily separated on other characters in all stages. The red colour of *R. sanguinea* is striking and together with the more variegated dorsal abdominal pattern and the obsolescent character of the femoral spots should make separation easy in the case of imagos and subimagos.

The nymph of *R. doddsi* McD. Needham (8) McDunnough (7) and Needham et al (9) has red gills and also the median lobe on the intermediate gills as has *R. sanguinea.* The genitalia of *R. sanguinea* and *R. impersonata* are, however quite different from those of *R. doddsi* which have conspicuous lateral spines basally. Dr. Traver has described several species of Rhithrogena from North Carolina, Traver (11 and 12), including *R. amica, R. rubicunda, R. sp. No. 2* known only in the nymphal and imago female stages and *R. sp. No. 3,* known only in the nymphal stages but suspected of being the nymph of *R. rubicunda.* The first two are similar in having a spatulate process on each penis lobe which is absent in both *R. impersonata* and *R. sanguinea. R. Sp. No. 2* has a faint lavender tint basally in the gills but the associated female imago has pale yellowish legs which possess the characteristic central femoral blotches which are obsolescent in *R. sanguinea* but present in *R. impersonata. R. Sp. No. 3* has deep purplish colour on the gills which differs in its distribution being confined to gills 2-6 rather than appearing, as does the red in *R. sanguinea* on all gills. Further, nymphs of this species are more contrastingly marked than are those of the latter. *R. fuscifrons* is known in the nymphal and female imago stages. In many details of structure of both nymph and female imago this species agrees with *R. imper-*

sonata and it may turn out to be this species. Daggy (2) has described *R. pellucida* from the Mississippi River at Minneapolis separating it from *R. impersonata* but leaving in abeyance its relation to *R. fuscifrons*. When male imagos are found the settling of the status of *R. fuscifrons* will be possible.

Discussion of the Habitat and Distribution of *R. sanguinea* n. sp. and *R. impersonata* McD.

The section of Sheldon Creek at which these two species of Rhithrogena were collected is about 10 miles downstream from the highest source located in the Singhampton moraine near the brow of the Niagara escarpment at a point about two miles south-east of the village of Primrose in Dufferin County. The stream, in this section, is from ten to fifteen feet wide and flowing fairly rapidly with numerous alternating pools and riffles. At the point it is flowing eastward through a deep cedar clothed valley cut through the Banks moraine. The valley in which the upper sections of the creek flow is, according to Chapman and Putman (1), a spillway which carried a glacial river flowing southward along the border of the ice during the recession of the last ice sheet. Sheldon Creek is now a tributary of the Nottawasaga River flowing northward to Georgian Bay.

This location is the only place to date at which *R. sanguinea* has been found although most of the main watersheds of Southern Ontario have been methodically examined in recent years in connection with surveys made by the Ontario Department of Planning and Development. *R. impersonata* had been taken at the Forks of the Credit in Peel County and in the Saugeen River in Grey County in addition to Sheldon Creek. Both species have, therefore, a spotty distribution and while it is probable that additional localities will be found it is felt that, as far as Southern Ontario is concerned, these will be in other rivers associated with the Niagara escarpment.

From the investigations of geologists it can be demonstrated that there has been much modification in stream courses in the past and particularly during the recession of the Wisconsin ice sheet across this part of Ontario. From its source in the Singhampton moraine Sheldon Creek flows eastward into a prominent spillway which carried a large river originating near the village of Singhampton and flowing southward between this moraine and the Gibraltar moraine (Galt moraine of Taylor) Chapman and Putnam (1) and Taylor (10). The river followed the escarpment closely, passing the Forks of the Credit, in whose channel the Credit River now flows at this point, flowed over the top of the escarpment near Georgetown, and eventually discharged into glacial Lake Warren. It is probable that the upper parts of Sheldon Creek were tributary to this river and that there was thus continuity of the rapid water habitat between Sheldon Creek and the Credit River when past history is taken into account. Sheldon Creek now crosses this ancient channel from west to east, traverses the Gibraltar moraine and then crosses another spillway. This latter is the channel of another glacial river of later time which flowed southward past the Forks of the Credit and then followed the course of the present Credit River below the escarpment for some distance. This latter spillway would afford continuity of rapid water conditions between Sheldon Creek and the Forks of the Credit of more recent date than in the former case. From its intersection of this latter spillway Sheldon Creek now flows eastward through a gap in the Banks moraine, following again a glacial channel, and joins the Nottawasaga river flowing northward to Georgian Bay. If the above interpretation is correct this is a good illustration of river piracy with streams which originally flowed to the south now flowing north. Chapman and Putnam (1) mention that the present streams have captured the glacial spillways in a number of places.

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The above relations may not be the explanation of the discontinuous distribution of these insects but with forms such as mayflies which have brief aerial existence and remain in close proximity to the place in the stream from which they emerge continuity of the aquatic habitat would seem to be more satisfactory than postulation of fortuitous distribution by wind or other agency. Especially would this be so in the case of species, like those under discussion, whose distribution is now restricted to local rapid water habitats in the rivers. It is quite probable that these insects were more widely distributed in the past. The changing courses of streams during and following the glacial recession has a significant bearing on this past history.

There are other elements of the stream fauna of this part of Ontario which show close affinities with those of parts of Michigan, Illinois, New York and the Laurentian and Appalachian highlands although this locality is now isolated from them. This phenomenon could be most satisfactorily explained on the basis of rivers flowing south in the past from the edge of the receding ice sheet up which elements of the fauna migrated and persisted to the present time in habitats which remained suitable. The existence of such rivers has been demonstrated but most of them appear to have emptied into large bodies of static water which would be effective barriers to the migration of rapid water forms from the south. From a study of the history of the great lakes and the history of their outlets and connections, Leverett and Taylor (5) possibilities of suitable rivers draining southward from this section of Ontario would seem to have been restricted either to the very early period of the removal of the ice sheet from Ontario, for example the time of early Lake Maumee, or to a much later period of glacial recession when the ice sheet had withdrawn from the face of the Niagara escarpment in the Niagara region but before the inception of Lake Iroquois in the Lake Ontario basin. This would correspond to the earliest stage of, or stage of transition to, Lake Algonquin the last of the glacial lakes in the region. The courses of the glacial rivers are incompletely known at the present time.

Relationship of *R. sanguinea* n. sp. and *R. impersonata* McD.

R. impersonata is, as far as present records show, restricted in Ontario to a few locations in the vicinity of the Niagara escarpment and *R. sanguinea* is apparently even more restricted having been found at only one place. The question arises as to whether the latter species has evolved in this habitat which it shares with *R. impersonata* and that a case of sympatric speciation is thus illustrated.

On criteria of the taxonomist these two species are closely related and yet readily distinguishable in both nymphal and adult stages. The most conspicuous difference in both stages is the red pigment of *R. sanguinea* which colours the gills and other parts of the nymph and is carried through into the subimago and imago, and the substitution in *R. impersonaata* of a pale green pigment which is quite noticeable in the femora and basal part of the tibiae in the living specimens but not evident in dried ones. There are other differences notably in ground colour and in the maculation of the abdomen and in the degree of prominence of the femoral spots and also structural differences as for example those of the gills which have been noted. These differences are comparable in magnitude to the differences which are used in the separation of species in the mayflies and the description of *R. sanguinea* as a new species seems warranted. On genitalic characters alone, however, the two are almost indistinguishable and by this criterion would be considered to be closely related. On the basis of genitalia, also, these species would be considered to be more distantly related to other known members of the genus than they are to one another.

The nymphs of both species occurred in the same rapids in the stream and were frequently intermingled on the same stone. *R. sanguinea* was scarcer than *R. impersonata*. As far as could be determined, without extensive quantitative analysis, the nymphs of both coincided in their stage of development and when their emergence was checked in the summer of 1952 it was found that both emerged on the same days and at the same time in the evening. More continuous sampling might show, however, that this was a case of extensive overlapping. Swarming of adult males and matings were observed on seven evenings and on each occasion both species were combined in a restricted swarm.

In this case, therefore, it is certain that there is no spatial or significant temporal segregation of the two species. Between many species of stream inhabiting mayflies there is no geographical, even microgeographic, isolation but in these there is, except in one or two cases similar to the present one, a separation of the mating activity in any one habitat in a seasonal or diurnal manner, Ide (3). Mayr, (6), has commented on one of these cases, and is of the opinion that, when such closely related mayfly species occur together in the same place in the same stream, it is a result of a secondary moving into the same habitat after having been geographically isolated at an earlier period. The presence of two closely related species of mayflies in the same restricted locality in a stream is very usual and in some instances three species which are more closely related to one another than to other species are found. The example treated in the present paper is, however, a stronger argument for sympatric speciation than are others in which there is temporal separation. Even in the latter instances, however, the case for sympatric speciation is strong as they would appear to have been evolved by the seasonal separation into two species of an ancestral continuously varying population. The author (4) has interpreted one such case of this type as incipient speciation.

The case of these two species of Rhithrogena is not absolute proof of sympatric speciation since as Mayr has pointed out the divergence may have taken place under conditions of geographical isolation and the two species later moved into the same habitat. If, however, we admit of such a possibility one of these species has moved back into the same geographical position as the other and its physiological attributes are such as to allow it to coincide in season and mating activity with the other. This would be a remarkable coincidence and would be unusual between closely related forms, and wider geographical distribution of both species would be expected if such had taken place.

Of thirteen pairs of Rhithrogena taken from the swarm and being associated in the mating position twelve were of a male *R. impersonata* with a female *R. impersonata* one was of a male *R. sanguinea* with a female *R. sanguinea*. These findings, although meagre, support a view that the males of the two species become associated with their respective females in the swarm. It is probable that they attempt mating with individuals of the other species since, as mentioned above, attempts to mate with the opposite sex of species of other genera were observed. In these latter cases the mating is probably not completed and might not be in the former if such took place.

The critical period for isolation of these two species apparently is in the mating swarm and since they are in the same place at the same time, sexual selection, one concludes, is the effective isolating mechanism allowing them to coexist. The evidence here presented supports the view that speciation may take

place where there is no spatial (geographical or microgeographical) or temporal isolation involved and that isolation is probably in the nature of sexual selection with interspecific incompatibility.

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Note on the Blow Fly *Phaenicia sericata* (Mg.) (Diptera: Calliphoridae) in Newfoundland

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In October, 1953, an estimated 20 per cent of the sheep in "The Green" section of Bell Island, Conception Bay, Newfoundland, were infested with blowfly larvae. In some instances the infestation was so severe that the sheep died from the attack.

Larvae collected from an infested sheep were reared on Pard (Swift Canadian Company, Toronto) dog food. The flies were considered by Mr. J. F. McAlpine, Systematic Entomology Unit, Entomology Division, Ottawa, to be of *Phaenicia sericata* (Mg.). Mr. McAlpine (in litt.) noted that the Newfoundland specimens differed slightly from Hall's concept of *P. sericata* in colour, degree of pollinosity, and width of frons in the male; however, a small series of reared adults was all that was available from Newfoundland and these differences may fall within the limits of variation for such a common, widespread species.

Phaenicia sericata is the principal species causing cutaneous myiasis of sheep in Britain, but it has not been recorded as troublesome on sheep in Canada (Hearle, 1938). This appears to be the first record of *P. sericata* as the causative agent of cutaneous myiasis on sheep in Newfoundland.

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Observations on Snow Insects in Western Montana

By JOHN A. CHAPMAN[1]

A number of reports on snow insects have been made by entomologists although many of them are brief and fragmentary. Brauer (1871) long ago considered the problem which winter represents for insect life and stated that *Boreus* (Mecoptera: Boreidae) and *Chionea* (Diptera: Tipulidae) and several members of the Collembola were true snow insects. Frey (1913) collected many insects from the surface of snow and listed representatives of the above mentioned groups from Finland, as well as a large number of insects whose presence on the snow was apparently accidental. Marchand (1917) made some interesting observations on the behaviour of *Chionea* and its temperature tolerance and referred to several earlier papers on this genus. Handschin (1919a) carried out an extended study of the snow zone fauna of the high Alps and took many specimens on the snow or on glaciers. However, he did not list *Boreus* and his Diptera had not been identified when he made his report. Collembola were dealt with in another publication (1919b).

Van Dyke (1919) pointed out that numbers of insects were to be found on summer mountain snow banks. Kaisila (1952) collected a surprising variety of insects from such snow banks in Finland. However, none of the typical snow insects mentioned above were found and they would not be expected in collections of this type.

The present report is based on a few collections and observations on snow insects prior to the autumn of 1952 and approximately 65 hours of search for, and observations on, snow insects at intervals during the winter of 1952-53 and the following spring. Many insects were found on the snow, particularly during thaws. Most of them, however, appeared to be present accidentally and represented the types which Frey dealt with primarily. These forms included various midges and other representatives of the lower Diptera, hemipterans, homopterans, some beetles, occasional hymenopterons and some stoneflies. Spiders also were frequently found. However, only those insects are further considered here which appeared to utilize the surface of the snow as at least one of their normal habitats. These insects are listed and various observations on their behaviour and the conditions under which they were found are given.

Temperatures were all measured with a pocket thermometer which could be read accurately to within 0.5° F. and represent readings taken with the thermometer bulb shaded and as close to the snow surface as possible without actual contact. This thermometer recorded 32.0° F. several times in melting snow. Unless otherwise indicated the locality is Missoula, Montana, and insects were taken on snow. Altitudes are estimations by the writer based on comparisons with several known points.

Coleoptera

Staphylinidae

Atheta spp. (two species represented)

6, II.53	3,800 feet	23 specimens
12, IV.53	3,500 feet	18 specimens

These small staphylinids were taken while making two of the few collections of Collembola. Fresh snow had fallen both nights before the beetles were found and total depth was several inches. The beetles were scattered among the

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snow fleas and occurred in numbers comparable to a fairly sparse population of the former. On both occasions they were actively crawling about on the surface of the snow and they were found in both wooded and adjoining open areas. The temperature on both dates was 32.0° F. On the earlier date hemipterans, several dipterons, leafhoppers and many *Boreus* and Collembola were also found in the general vicinity. On the latter date only the last two forms were seen in addition to the beetles. The numbers and activity of the staphylinids definitely suggested that they were at home on the snow.

Lepidoptera

Geometridae

Operophtera sp. (near or=*occidentalis* (Hlst.))

16, X.52 3,700 feet Bonner, Montana 11 specimens

These insects, all females, were taken on the surface of fresh snow of about six to eight inches depth. Many more of the moths were seen scattered over a brush area several dozen square yards in extent. They were all crawling about on the snow and resembled *Chionea*, being wingless, and similar in size. No males, which are winged, were noted at this site. Although several miles were covered in the general vicinity of this area on the same day no other moths were found. The temperature was estimated to be close to freezing although the snow was not obviously melting at the time. The sky was overcast all that day. It is interesting to note that a related species, *O. brumata*, the winter moth, typically emerges from the pupal stage in late autumn, and that adults of this species are quite resistant to low temperatures (Kozhanchikov, 1950).

Collembola

Onychiurus cocklei (Folsom) the golden snow flea

10, V.51 5,500 feet
29, III.52 3,200 feet

Achorutes near *nivicolus* (Fitch)

6, II.52 3,800 feet
9, III.52 3,600 feet
13, III.52 3,500 feet

Agrenia bidenticulata (Tlb.)

9, III.52 3,600 feet

Vertagopus arborea (L.)

9, IV.51 3,600 feet

Isotoma grandiceps Reuter

6, II.53 3,800 feet

Isotoma viridis (Bourlet)

6, II.53 3,800 feet

No attempt was made to collect these insects extensively as their occurrence on snow is well known and many of them have a wide geographical distribution. The collembolans were found to be active only at times when temperatures were close to or above freezing and occurred most abundantly on melting snow. With the exception noted below they were seen in fairly small numbers and were well scattered on the snow surface. At times only a few specimens would be seen in any one area.

The golden snow flea appeared on March 29, 1952, at the Missoula airport in very large numbers following a spring rain which came while snow was still on the ground. At that time they formed quite conspicuous yellow patches on the

snow in certain areas. Persons who had worked at the airport for several years said that they had not noted, nor heard of these insects prior to that time. Patches of bare earth were present adjacent to the insects.

Mecoptera

Boreidae

Boreus unicolor Hine

6,	II.53	4,000 feet	30 males, 35 females (including three mating pairs)
11,	II.53	4,000 feet	23 males, 17 females (including three mating pairs)
13,	III.53	3,500 feet	10 males, 2 females
6,	IV.53	3,500 feet	1 male, 3 females

Boreus reductus Carpenter

6,	II.53	4,000 feet	2 males, 4 females (including one mating pair)
11,	II.53	4,000 feet	1 male
14,	II.53	4,000 feet	1 female

*Boreus sp.**

20,	IX.52	7,400 feet	Ronan, Montana 1 specimen

The largest numbers of *Boreus* were noted after fresh snow had fallen the previous night. As a general rule there was no bare earth in areas where the insects were taken. They were often quite scattered and at times several minutes search in an area was necessary in order to find each specimen. Frequently, but not always, Collembola were also present in the general vicinity and at times other types of insects and also spiders were noted.

The insects were found in rather localized areas. For example, on February 6 some six miles were carefully covered in a search for snow insects but in only one brush covered area near the forest were they found. Specimens were never seen above 4,000 feet on snow and often none were found on trips lasting several hours. In the spring, when areas in which they had been noted in greatest numbers were only partly snow covered, careful search failed to reveal any of the insects. The single specimen from Ronan was taken under a rock high in the Mission mountains. No snow had fallen for several days and no snow was then present in the area.

These insects exhibited considerable jumping activity on the snow surface at 32.0° F., the temperature at which they were most frequently found. The lowest temperature at which they were taken was 29.0° F. On February 11 some 30 specimens were taken and placed outdoors in a shaded container partly filled with snow. The following morning snow surface temperature measured 22.0° F. but at least some of the insects were still crawling slowly about. The next morning the temperature was 31.0° F. and all specimens showed considerable activity. Four pairs were seen *in copula*. Some of the specimens were kept in this container until February 28 and survived a cold spell when the temperature dropped to 10.0° F., at which time the insects were observed to be entirely motionless. On another occasion, at 19.5° F., one of the specimens was seen to move its antennae slowly and to shift its position slightly.

An interesting behaviour pattern was observed many times. When the insects were approached or the snow near them touched they would frequently

*Specimen lost before species determined.

suddenly retract their legs and remain motionless on the snow from several seconds to a minute or more. Some individuals did not show such a response, however. At no time was any attempt by the insects to burrow under the snow surface noted.

Diptera

Tipulidae

Chionea alexandriana Garrett

–, XI.50	4,500 feet	Lolo, Montana	1 male, 1 female
9, III.52	3,600 feet	1 male	
21, XII.52	3,600 feet	3 males	
6, II.53	4,200 feet	2 males	
14, II.53	6,000 to 7,200 feet	Lolo, Montana	14 males, 12 females, 2 pairs *in copula* in captivity
14, III.53	6,500 feet	Lolo, Montana	2 males, 1 female
8, IV.53	6,000 to 7,000 feet	Lolo, Montana	7 males, 6 females
16, V.53	7,000 feet	Lolo, Montana	1 male, 1 female

Chionea albertensis Alexander

–, XI.50	4,500 feet	Lolo, Montana	1 male

Chionea nivicola Doane

16, II.52	3,600 feet	1 female	

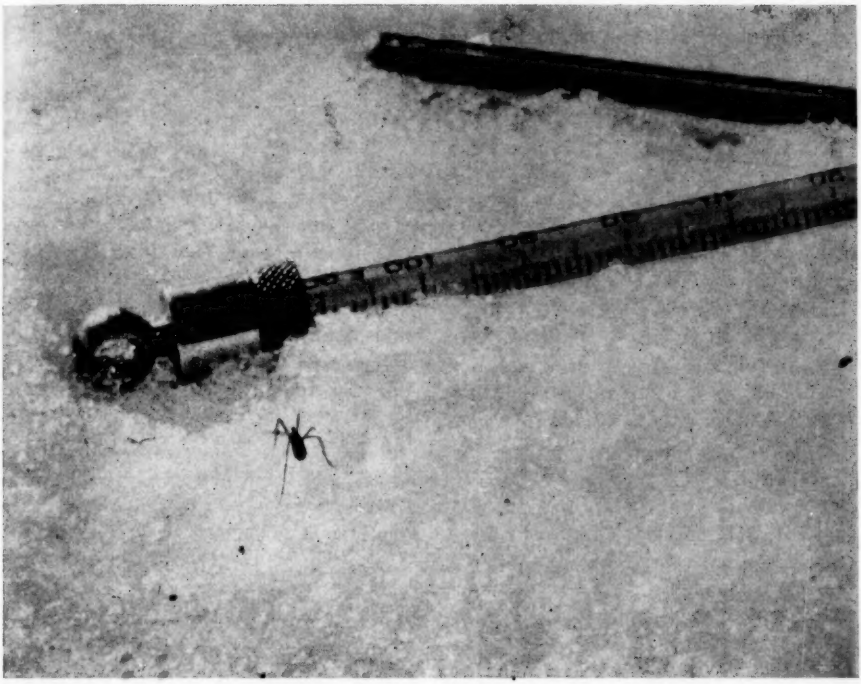
Chionea sp. (new species being described by G. W. Byers)

4, X.52	8,000 feet	Seeley Lake, Montana	1 female
21, XII.52	3,600 feet	1 female	

The *Chionea* specimens were usually found walking in a straight line in their characteristic rather peculiar manner which is reminiscent of a mechanical model (note photograph of *Chionea*). Only two individuals were motionless on the snow when first seen. Although they resemble spiders somewhat their manner of locomotion is quite different and in all cases where spiders were noted on snow in the same general area the insects were moving far more rapidly. On two dates of collection fresh snow was falling at the time the insects were taken, and all but four or five specimens were found after a fresh snowfall the previous night.

A characteristic behaviour pattern was shown by many of these insects. Immediately after bending over them, or placing a snowshoe or branch beside them, they would suddenly retract their legs and become motionless, exhibiting a definite akinesis. One specimen was seen to remain in this condition for ten minutes and several others for two to five minutes, before suddenly becoming active and continuing on their way. However, some individuals would not show this response even when picked up or touched. This type of behaviour was previously reported for *Chionea* by Treherne (1920).

In an attempt to secure information on the destination of the *Chionea* moving on the snow surface considerable time was spent on April 8, 1953, observing them and placing various obstructions in their path. Although most specimens when found were within a few feet of trees, and presumably must have left trees or associated snow crevices prior to capture, when under observation they showed a definite inclination to climb into natural and artificial crevices or pits in the snow. They would climb up and then usually down underneath pine or fir branches placed in their path, remaining out of sight for a half minute to several minutes before appearing on the snow and walking away from the



Chionea, male on old snow May 16, 1953, 7,000 ft.
(Photo by Edward McCurdy).

branch. When a pit was made by pushing a branch into the snow they would crawl down into it. Some individuals would have crawled down out of sight into crevices at the bases of trees had they been permitted to do so. The insects would not climb onto a hand or finger and, as reported by Marchand (1917), appeared to be repelled somewhat by them, perhaps because of their warmth. No attempt by these insects to burrow in the snow was ever noted and it is very doubtful if they have the physical strength necessary for such activity.

These insects were never numerous nor were they found closer together than several yards, although with each capture the immediate area was carefully searched for additional material. Frequently a search of several hours would reveal only two or three individuals. For example, on May 16, 1953, an entire day was spent in high mountain areas with two other persons and only two specimens were found. The only mating activity noted occurred during captivity when two out of a possible ten pairs were seen *in copula*. On only two occasions were any *Boreus* seen in the same general areas where *Chionea* were found. The latter were taken with greatest frequency above 5,000 feet in the Bitterroot Mountains. Here snow depth was often two and a half to three feet at the time of collection. However, it may be noted that even in such areas some access to soil was undoubtedly to be found where partly buried branches of smaller trees or leaning windfalls provided it.

The single exception to snow surface capture of *Chionea* occurred on October 4, 1952, when one was found under a rock at 8,000 feet in the Swan

B & Z Library

Mountains. No snow was present in the area nor had there been snow for several days although frost was to be found under most rocks.

These insects were taken without exception in forested areas. They were never seen in grassland sites although there was frequent opportunity to notice them in such areas. Most of the tree species found in the mountains of western Montana were represented in different areas where specimens were taken but lodgepole pine (*Pinus contorta*) and Douglas fir (*Pseudotsuga taxifolia*) were by far the most common trees at these sites. There was little or no noticeable wind during the most fruitful collection periods and on several occasions vigorous shaking of smaller trees in the areas where specimens were taken did not yield additional material. It is therefore considered unlikely that the insects found had fallen onto the snow from trees.

It should be mentioned that although mornings were as well represented in collecting periods as afternoons most of the specimens were found between one and four p.m. One twilight hour search was made in the best collecting area but it was unsuccessful.

Chionea specimens were found to exhibit activity at surprisingly low temperatures. On March 9, 1952, one individual was found crawling slowly but surely along the snow in the late afternoon at a temperature of 22.0° F. At this time snow temperature approximately one inch beneath the surface was 31.0° F. A few snowfleas noted in the area were completely motionless. On February 14, 1953, some 20 specimens were taken alive and kept outdoors for several days in a shaded jar containing snow. On February 19, morning temperature was 21.5° F., but one insect was seen to climb slowly up the side of the jar. No locomotion was seen in adjacent *Boreus* specimens. At a later date at 19.5° F. most *Chionea* were motionless, some lying on the snow, although some leg movement and shifting of body position was seen in one individual. On another occasion at 22.0° F. a captive specimen was seen to climb slowly up a small twig. On March 14, 1953, one individual was found on deep snow at a temperature of 20.0° F. and two others later the same day at 22.0° F. All three of these insects were walking actively when first noted. On April 8, 1953, a specimen was found walking at the rate of close to three feet per minute at a temperature of 27.5° F. A nearby spider was crawling at about three inches per minute. On the same day at higher altitudes two other *Chionea* specimens were found, walking over two feet per minute at 21.0° F.

In connection with the relationship between activity and snow surface temperatures attention was paid to the effect of sunshine on the insects. Most successful collecting was carried out on days when the sky was overcast and no definite shadows could be seen. However, on March 14, 1953, the sky was clear. None of the three specimens found then appeared to show the slightest response or change in activity upon crawling from shaded areas into patches of direct sunlight, or vice versa.

It is obvious that *Chionea* and *Boreus*, particularly the former, show a considerable degree of adaptation to the environment in which they are active as adults. The essentially wingless condition and the similarity of their akinesis resulting from vibrational and possibly visual stimulation are perhaps parallel developments correlated with the ecological characteristics of their habitat. It is suggested that this behaviour may be of significance as a protective mechanism. Certainly both forms are easy to see on the snow when they are moving about.

Both insects are holometabolous and presumably can do without food in the adult stage, although the question of their feeding on the snow surface remains to be clarified. During these studies none were seen showing activity that could be interpreted as feeding behaviour. It is interesting that *Boreus* hops a great deal, whereas the locomotion of *Chionea* is a steady walk, with little or no apparent variation in rate.

In capacity to move about at low temperatures these insects certainly rank with *Grylloblatta*, which has been reported as showing normal activity at from about 32° to 36°F. and succumbing to cold prostration at close to 21°F. (Mills and Pepper, 1937). Actually, *Chionea* may well surpass this form in extent of normal activity at low temperatures.

Many phases of the life history and biology of these interesting insects remain to be determined although some information of this type is available (see Williams, 1916; Edwards, 1935; Cooper, 1940; Crampton, 1940). Careful and extended studies are needed in order to answer many of the questions which arise concerning their ecology. Determinations of the relationship between air temperatures immediately above the snow to body temperature and activity of the insects would undoubtedly contribute to an explanation of how these forms are able to utilize the snow surface as their adult habitat.

Acknowledgments

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Carabid Beetles from Eastern and Southern Labrador

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The beetle fauna of Labrador, like the literature dealing with it, is very poor. Besides old records of single species and incomplete lists, the only papers of importance are those by Sherman (1910), Brown (1930, 1932), and Eidmann (1935), and only Sherman lists all of the Labrador species known at the time. The fauna of northernmost Labrador is touched upon by Blair (1933) and Brown (1937).

My interest in the Labrador carabid fauna, as explained in an earlier paper in this journal on the carabids of Nova Scotia, comes from a need for knowledge of the fauna of the mainland that is adjacent to Newfoundland, which island is the main concern of my research. The sources used are likewise the same, and I wish to give sincere thanks here to the Rockefeller Foundation, which enabled me to study in North American museums. In the British Museum I saw much material collected at Hopedale in 1935 by W. W. Perrett.

My own Labrador collecting in 1951, between Battle Harbour and Forteau extended from July 9 to 20. I was accompanied by a Newfoundland student, John E. Steele of St. John's, who captured *Diachila* as well as other species. A complete collection of the Labrador species taken in 1951 will be deposited with the Department of Agriculture, Ottawa, together with the main part of the carabid material on which Mr. John D. Sherman, Jr., founded his paper (1910) and which has been generously placed by him at my free disposal.

The area considered in this paper is not the whole of the Labrador peninsula but is limited to the southern and eastern parts, north to Port Burwell and Cape Chidley, at the entrance to Hudson Strait. The western boundary was arbitrarily fixed at Thunder River, opposite the western end of Anticosti Island. Therefore, the district covered by Eidmann's investigation falls outside our area, as do two localities, Trinity Bay and Seven Islands, of the lists of Brown (1930, 1932). Only two species, *Cicindela repanda* Dej. and *Pterostichus coracinus* (Newn.), become excluded thereby. Up to the present, practically all collecting in Labrador, including that in the region of Hamilton Inlet, has been done on the coastal strip, so there is no need to define a western limit except to note that Ungava Bay, in the north, is excluded.

Usually I have given only an outline of the Labrador distribution of the species. Unfortunately, the exact localities of museum specimens was not always noted.

It is perhaps worth mentioning that the beetles from West St. Modest treated by Sherman (1910) and constituting more than half of his material were collected by Ernest Doane (Sherman, 1913), a most remarkable man, a true field naturalist who hunted, collected, and preserved all kinds of animals. He lived for a very long time at West St. Modest before he passed away in 1948. His person and interests are spoken of proudly by the people of that small outport.

The abbreviations used below are:

AMN–American Museum of Natural History, New York.
BMN–British Museum, Natural History, London.
DAO–Department of Agriculture, Ottawa.
NMW–National Museum, Washington, D.C.

Bwn–W. J. Brown.
Lth–C. H. Lindroth.
!–the exclamation point indicates that the material was seen by myself.

The list includes 82 species, besides one dubiously recorded.

List of Species

Cicindela duodecimguttata Dej.–Natashquan (Brown, 1930, p. 231!); Goose Bay (DAO!).

C. hirticollis Say.–Thunder River (DAO!); Natashquan (Brown, 1930, p. 231).

C. longilabris Say.–Thunder River (Brown, 1932, p. 199!); Natashquan (Brown, 1930, p. 231!); North West River, Hamilton Inlet, June, 1936 (BMN!). The single specimen from Hamilton Inlet, the two from Natashquan, and three of the 18 from Thunder River belong to the bright green form, *novaterrae* Leng. Frost's Labrador record (1935), "Spoagdale", is false; I was informed by Miss Marion E. Smith of Massachusetts University that it applies to Springdale, Nfld.

C. tranquebarica Hbst.–Natashquan (Brown, 1930, p. 231!).

Carabus chamissonis Fisch. (*Carabus* sp., Brown, 1930, p. 231; *C. groenlandicus* Dej., Brown, 1932, p. 199).–Okkak, 57°30'N. (Packard, 1872, p. 92; 1891, p. 390); Hopedale (Sherman, 1910, p. 176; DAO!; BMN!); several localities, Domino Harbour to Bonne Esperance (Packard, l.c.; Brown, l.c.; Lth.); Belle Isle (C. F. dos Passos, AMN!). The species lives on high, open ground with *Empetrum* and associated plants.

C. maeander Fisch.–Fog Island to Bradore Bay, four localities (Brown, 1930, p. 231; 1932, p. 199!).

Elaphrus Clairvillei Kby.–Forteau, three examples (Lth.).

E. lapponicus Gyll. (*obscurior* Kby., *obliteratus* Mnh.).–Battle Harbour, four examples among *Marchantia* and sparse *Carex* at the margin, near the mouth, of a very small river, also one third-stage larva (Lth.); West St. Modest, one specimen (Sherman, 1910, p. 176); Forteau, one third-stage larva with *Blethisa* (Lth.). Suitable habitats for this insect were searched in vain in 1951 at West St. Modest; perhaps the season was too late, as the insect is definitely a spring species in Europe.

E. riparius (L.).–Natashquan (Brown, 1930, p. 231!).

Diachila arctica amoena (Fald.) (*subpolaris* Lec.).–Red Bay, one female in a small sphagnum swamp (Lth.).

Blethisa multipunctata aurata Fisch. (*hudsonica* Csy.).–Forteau, *Carex-Sphagnum-Menyanthes*-pool on the plateau, July 14, two third-stage larvae (Lth.).

Loricera pilicornis (Fbr.) (*coerulescens auct., neoscotica* Lec.).–Thunder River to Battle Harbour, several localities (Sherman, 1910, p. 176; Brown, 1932, p. 199!; Lth.).

Notiophilus aquaticus (L.) (*Hardyi* Putz.).–Several localities, Thunder River to Battle Harbour (Brown, 1930, p. 231!; 1932, p. 199!; Sherman Collection!; Lth.).

N. borealis Harr.–Cartwright (Bwn., DAO!); Domino Harbour (Packard, 1872, p. 92; 1891, p. 390 "*sibiricus*"; Sherman, 1910, p. 176); Battle Harbour (AMN!); West St. Modest (Sherman Collection!); Henley Harbour and Forteau (Lth.). The record from Square Island (Packard, l.c.) may refer to the preceding species.

N. n. sp.–West St. Modest, one example; Pinware River, on sand at the mouth, two examples (Lth.). This species, known also from Newfoundland, Manitoba, and Alaska, will be described in my Newfoundland paper.

Pelophila borealis (Payk.).–Very common along the coast from Kegashka River to Battle Harbour (Sherman, 1910, p. 177; Brown, 1930, p. 231!; Lth.); also known from Hopedale (BMN!), and from the interior but without exact locality (Fletcher, 1896, p. 333). The Labrador form has passed under the names *Ulkei* Horn, *Shermani* Csy., and, wrongly, *rudis* Lec., but it constitutes at most a subspecies of *borealis* (*vide* Bänninger, 1930, p. 100). Whether it, under the name *Shermani*, should be separated from *Ulkei*, described from Hudson Bay Territory, is uncertain. The true *rudis* is specifically distinct and is unknown from Labrador; its type locality, Methy, is situated in Saskatchewan (against Bänninger, l.c.).

Nebria Gyllenhali castanipes (Kby.) (*moesta* Lec.; *Sahlbergi auct., partim, nec* Fisch.; *labradorica* Csy.; *prominens* Csy.; *curtulata* Csy.).–Common between Natashquan (Bwn., DAO!) and Battle Harbour (Sherman, 1910, p. 177; Brown, 1930, p. 232!; Lth.); Sloope Harbour (25 miles south of Cape Harrison, Packard, 1872, p. 92; 1891, p. 390); also in the interior but without exact locality (Fletcher, 1896, p. 333). Whether the record of "*Sahlbergi*" from Cape Chidley in the extreme north (Bell, 1885, p. 27; Harrington, 1890, p. 190) refers to *bifaria* Mnh. is still undecided (Brown, 1937, p. 107).

Dyschirius aeneolus Lec.–Thunder River (Brown, 1932, p. 199, "*Dyschirius* sp."; DAO!, compared with LeConte's type!).

D. Helleni J. Müll. (*norvegicus* Munst., *secretus* Fall).–Forteau, one female in moss in a dense bush-wood near a rivulet; seen also from Manitoba and Alaska.

Bembidion (*Chrysobracteon*) *carinula* Chd.–Thunder River and Natashquan (Brown, 1932, p. 199!); Pinware River, abundant on sandy banks at the mouth (Lth.).

B. (*C.*) *carrianum* Csy. (*litorale auct.* American, *nec* Ol.; *lacustre* Fall, *nec* Lec.).–Natashquan (Brown, 1930, p. 232).

B. (*Plataphodes*) *occultator* Notm.–Forteau, 14 examples; L'Anse au Loup, one example; Pinware River, two examples; Red Bay, one example; occurs beneath overhanging bushes on river banks.

B. (*Plataphus*) *lenense* Popp.–L'Anse au Loup and Pinware River, abundant in sterile gravel along river banks (Lth.). Known also from Newfoundland, British Columbia, Yukon Territory, and Alaska.

B. (*P.*) *rusticum* Csy. (*planiusculum auct., nec* Mnh.).–L'Anse au Loup, common with *lenense*; Pinware River, one example (Lth.). Possibly Sherman's "*longulum*" (1910, p. 177) belongs here. The specimen is not in his Labrador collection, nor in the collection of Hayward, who received Sherman's material for identification.

B. (*P.*) *Grapei* Gyll. (*picipes* Kby., *nitens* Lec.).–Several localities between Natashquan to Goose Bay (Sherman, 1910, p. 178!; Brown, 1930, p. 232!; DAO!; Lth.), Hopedale (BMN!). On rather dry, often peaty, soil.

?*B.* (*P.*) *scopulinum* (Kby.).–Listed from Labrador by Leng (1920, p. 51) but possibly not from the region considered here. Known from Anticosti Island (MCZ!).

B. (*P.*) *petrosum* Gebl. (*lucidum* Lec., *nec auct., substrictum* Lec.).–Pinware River, abundant on sandy banks at the mouth (Lth.).

B. (*P.*) sp. ("near *tetracolum* Say" Brown, 1930, p. 232).—Natashquan (DAO!). This species, related to *bimaculatum* (Kby.) and *sordidum* (Kby.), is probably undescribed. I have seen only two females.

B. (*P.*) *sejunctum* Csy.—Natashquan (Brown, 1930, p. 232, "*fuscicrum* Mots.?", DAO!).

B. (*Eupetedromus*) *incrematum* Lec. (*arcuatum* Lec., *nigripes* Mnh., *nec* Kby.).—Thunder River (Brown, 1932, p. 199, "*graciliforme*", DAO!); Pinware River, one example (Lth.).

B. (*Notaphus*) *nigripes* (Kby.).—Natashquan (Brown, 1930, p. 232!) and Goose Bay, July, 1948, many examples (DAO!).

B. (*Furcacampa*) *decipiens* Dej. (*versicolor* Les., *nec* Csy.).—Thunder River (Brown, 1932, p. 199!); Pinware River, one example (Lth.).

B. (*Diplocampa*) *transparens* Gebl. (*sulcatum* Lec.).—Thunder River (Brown, 1932, p. 199!); Forteau, one example (Lth.).

B. (*Amerizus*) *oblongulum* (Mnh.).—Forteau, five examples (Lth.); West St. Modest (Sherman, 1910, p. 178!).

Trechus apicalis micans Lec. (*borealis* Schffr.).—Many localities, Thunder River to Islet Bay (Lth.) and Battle Harbour (type locality of *borealis*, NMW!, Sherman Collection!) (Sherman, 1910, p. 178, "*rubens*"; Brown, 1930, p. 232; 1932, p. 199!); Goose Bay (DAO!).

T. chalybaeus n. subsp.—Forteau, L'Anse au Loup, West St. Modest, Henley Harbour, Islet Bay, Battle Harbour (Lth.); Cartwright and Hopedale (DAO!). The subspecies will be described in my Newfoundland paper and is known also from the mountains of New York, Vermont, New Hampshire, and Maine.

Patrobus fossifrons stygicus Chd. ("*septentrionis*", Brown, 1930, p. 232; at least partly also in Sherman, 1910, p. 178).—Many localities between Harrington Harbour (Bwn!) and Battle Harbour (Sherman Collection, Lth.).

P. foveocollis (Esch.) (*tenuis* Lec.; "*septentrionis laeviceps*", Brown, 1932, p. 199).—Many localities between Bradore Bay (Bwn!) and Battle Harbour (Lth.). There is no reason to treat *tenuis* as a different subspecies (cf. Darlington, 1938, p. 169).

P. septentrionis labradorinus Csy.—Forteau, three examples; Red Bay, nine examples; Henley Harbour, six examples; Battle Harbour, common (Sherman Collection!; Lth.); Hopedale (DAO!).

Pterostichus (*Lyperopherus*) *punctatissimus* (Rand.).—Several localities between Mingan (MCZ!) and Battle Harbour (Sherman, 1910, p. 178; Brown 1930, p. 232!; Lth.).

P. (*Stereocerus*) *haematopus* (Dej.) (*Amara* or *Curtonotus haematopus*).—Many localities, from Net Island (Brown, 1930, p. 233!) to Port Burwell (Brown, 1937, p. 108), in the extreme north (Packard, 1870, p. 119; 1872, p. 92; 1891, p. 389; Sherman 1910, p. 180!; BMN!, DAO!, Lth.). Mostly on dry ground with *Empetrum* and associated plants. Van Dyke's record (1924, p. 8) of *P.* (*Lyperopherus*) *agonus* Horn from Labrador is certainly due to a misidentification, as already suggested by Brown (1949, p. 232), and is probably based on *haematopus*. In the Fall Collection (MCZ!), a specimen of this species stands as "*agonus*", which, as recognized at present, is a collective species.

P. (*Cryobius*) *brevicornis* (Kby.) (*mandibularis auct. nec* Kby.).—Several localities from Bonne Esperance (Brown, 1930, p. 232, "*Cryobius* spp.") to Battle Harbour (Lth.), Hopedale (Sherman, 1910, p. 179; BMN!). Blair's record of

mandibularis from Port Burwell, Hudson Strait, refers to *arcticola* (*vide* Brown, 1937, p. 108; BMN!). Leng's "*hudsonicus* Lec." (1920, p. 58) from Labrador almost certainly belongs to *brevicornis*.

P. (*C.*) *arcticola* Chd.—Abundant along the coast from Port Burwell in the extreme north (Brown, 1937, p. 107) to Battle Harbour (22 examples, Lth.). Among the large series of *Cryobius* from Labrador (DAO, MCZ, NMW, BMN, Lth.), only two species are represented. Therefore it seems probable that *labradorensis* Chd. is either a synonym of *arcticola* or a species of another region.

P. (*Argutor*) *patruelis* (Dej.).—Forteau, L'Anse au Loup, West St. Modest, Islet Bay (Lth.).

P. (*Bothriopterus*) *adstrictus* Eschz. (*Luczotii* Dej., *orinomus* Kby, and many other synonyms).—Abundant everywhere from Thunder River to Battle Harbour (Sherman, 1910, p. 178, 179!; Brown, 1930, p. 232, also "*Bothriopterus* sp."!; Lth.), Hopedale (BMN!).

Amara (*Cyrtonotus*) *torrida* (Ill.) (*rufimana* Kby., *brevilabris* Kby., *reflexa* Putz., *cylindrica* Lec., *labradorensis* Csy., *scrutata* Csy.).—Very common from Thunder River to Battle Harbour (Sherman, 1910, p. 179!; Brown, 1930, p. 232 and 1932, p. 199!; Lth.), Hopedale (Sherman, l.c.; BMN!), Belle Isle (C.F. dos Passos, AMN!).

A. (*C.*) *alpina brunnipennis* Dej. (*obtusa* Lec., *subtilis* Csy.).—Common in the north (Sherman, 1910, p. 179; Brown, 1937, p. 108; BMN!); along the coast south to Forteau (Lth.) and Bonne Esperance (Brown, 1932, p. 199!).

A. (*C.*) *hyperborea* Dej. (*elongata* Lec., *imperfecta* Brown, *peregrina* Mor., *Harpalus simulans* J. Sahlb.).—Several localities from Bradore Bay (Brown, 1930, p. 232!) to Hopedale and Nain (Sherman, 1910, p. 180!; DAO!; BMN!; Lth.). The "*hyperborea*" of Bell (1885, p. 27) and Harrison (1890, p. 190) is probably *alpina brunnipennis*.

A. (*Bradytus*) *apricaria* (Payk.) (*Putzeysi* Horn).—Thunder River (Brown, 1932, p. 199!), Forteau (Lth.), West St. Modest (Sherman, 1910, p. 180, "*Schwarzi*"!; Lth.).

A. (*B.*) *fulva* (Deg.).—Thunder River and Natashquan (Brown, 1930, p. 233, "*exarata*"; 1932, p. 200!).

A. (*B.*) *glacialis* (Mnh.) (*nainensis* Csy.).—Hopedale and Nain (Sherman, 1910, p. 180!; Casey, 1918, p. 239!). Study of specimens (Fall Collection, MCZ) from Bernard Harbour and Cockburn Point, N.W.T., show that the characters given by Casey vary, even within small populations. Casey's type is a normal *glacialis*, which otherwise is not represented in his collection.

A. (*Celia*) *Quenseli* (Schh.) (*remotestriata* Dej.).—Thunder River (Brown, 1932, p. 200!), Nain (Sherman, 1910, p. 180!); searched for in vain in the interjacent region in 1951.

A. (*C.*) *discors* Kby. (*gibba* Lec.).—Thunder River (Brown, 1932, p. 200, "*Celia* sp."!).

A. (*C.*) *erratica* (Dft.).—Forteau (Lth.), West St. Modest (Sherman, 1910, p. 180!, Lth.), Red Bay and Goose Bay (DAO!), Hopedale (Sherman, l.c., "*interstitialis*"!; DAO!; BMN!).

A. (*C.*) *subaenescens* Cki. (*subaenea* Lec.).—Thunder River (Brown, 1932, p. 200!); L'Anse au Loup, a dead specimen on the seashore, possibly a straggler (Lth.).

A. (*s. str.*) *aeneopolita* Csy.—Thunder River (Brown, 1932, p. 200, "*enervis* Csy.?"!).

Calathus micropterus ingratus Dej. (*confusus* Lec., *labradorinus* Csy.).—Common from Thunder River to Battle Harbour (Sherman, 1910, p. 181!; Brown, 1930, p. 233!; Lth.), Nain (Sherman, l.c.). According to Packard (1872, p. 92), occurring over the whole coast from Eskimo River to Hopedale.

C. advena (Lec.) (*Pristodactyla advena*).—Mingan Islands (Brown, 1930, p. 233!), West St. Modest (Sherman, 1910, p. 181!).

Agonum (*Platynus*) *Mannerheimi stygicum* (Lec.) (*maurum* Mtsch.).—Four localities, Forteau to Red Bay (Sherman, 1910, p. 181!; Lth.).

A. (*P.*) *sinuatum* (Dej.).—Goose Bay (DAO!). The record of Packard (1872, p. 92; 1891, p. 390) from Belles Amoures (off Forteau), referred to by Sherman (1910, p. 181), possibly refers to the foregoing species.

A. (*s. str.*) *placidum* (Say).—Thunder River (Brown, 1932, p. 200!).

A. (*s. str.*) *carbo* (Lec.) (*affine* Kby.).—Pinware River, Henley Harbour, and Battle Harbour (Lth.); Hopedale (DAO!).

A. (*s. str.*) *mutatum* G. and H. (*atratum* Lec.).—Goose Bay (DAO!).

A. (*Agonodromius*) *Bogemannii* (Gyll.) (*obsoletum* Say).—Thunder River and Bradore Bay (Brown, 1932, p. 200!), Mingan (MCZ!).

A. (*A.*) *quadripunctatum* (Deg.).—Thunder River and Bradore Bay (Brown, 1930, p. 233!); Mingan (MCZ!); L'Anse au Loup, a dead example on the shore (Lth.); West St. Modest (Sherman, 1910, p. 181!); Goose Bay (DAO!).

A. (*Europhilus*) *gratiosum* (Mnh.) (*lenum auct., nec* Dej.; *ruficorne* Lec.).—Forteau, one example (Lth.).

A. (*E.*) *sordens* Kby. (*picicorne* Lec.).—Goose Bay (DAO!).

A. (*E.*) *consimile* (Gyll.) (*invalidum* Csy.).—Common in *Carex-Sphagnum* bogs from Forteau to Battle Harbour (Lth.), West St. Modest (Sherman, 1910, p. 181, "*sordens*"!).

Lebia moesta Lec.—Thunder River (Brown, 1932, p. 200!).

Metabletus americanus (Dej.).—Thunder River and Natashquan (Brown, 1930, p. 233, "*Blechrus glabratus*"; 1932, p. 200!).

Cymindis cribricollis Dej.—Thunder River, Natashquan, and Bradore Bay (Brown, 1930, p. 233; 1932, p. 200!); Mingan (MCZ!); Forteau (Lth.).

C. unicolor Kby.—West St. Modest (Sherman, 1910, p. 181); Red Bay, one example (Lth.).

Miscodera arctica americana Mnh.—Bradore Bay (Brown, 1930, p. 233!); Foreau, one example (Lth.).

Harpalus affinis (Schrk.) (*aeneus* Fbr., *viridiaeneus* Beauv.).—Natashquan (Brown, 1930, p. 233!).

H. Baergi Cki. (*rufimanus* Lec.).—Thunder River (Brown, 1932, p. 200!); L'Anse au Loup, a dead male, without head and prothorax but with the characteristic genitalia, on the seashore; probably a straggler (Lth.).

H. laticeps Lec.—L'Anse au Loup, one dead but complete male on the seashore, certainly a straggler (Lth.).

H. fuliginosus (Dft.).—Mingan, 1881, one example (MCZ!); Forteau, a dead example on the shore (Lth.); Goose Bay, 1948, two examples (DAO!).

H. nigritarsis proximus Lec. (*recensus* Csy., *nec* Brown, 1930).—Mingan (MCZ!); Bradore Bay (DAO!); West St. Modest (Sherman, 1910, p. 182, "*herbivagus proximus*"!); several localities, often abundant, from Forteau to Battle Harbour (Lth.); Square Island (Packard, 1872, p. 92; 1891, p. 389).

H. pleuriticus Kby.—Thunder River (Brown, 1932, p. 200!).

H. fulvilabris Mnh.—Bradore Bay (Brown, 1930, p. 233, "*recensus*"!), West St. Modest (Sherman, 1910, p. 182!).

Trichocellus cognatus (Gyll.) (*ruficrus* Kby.).—Many localities, abundant from Thunder River to Battle Harbour (Sherman, 1910, p. 182!; Brown, 1930, p. 233!; MCZ!; Lth.).

T. (*Oreoxenus*) *Porsildi* Brown.—Hebron (Brown, in litt.); seen from Ungava Bay (NMW!), which is outside of our area in northern Labrador.

Bradycellus (*Catharellus*) *Lecontei* Cki. (*cordicollis* Lec.).—Thunder River (Brown, 1932, p. 201!), Natashquan (DAO!).

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The Functions of the Eyes and Antennae in the Orientation of Adults of *Neodiprion lecontei* (Fitch)[1]

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A recent paper (2) described the light reactions of *Sarcophaga aldrichi* Parker when the eyes of the fly were treated in different ways. The present paper describes a similar series of observations on adults of the sawfly, *Neodiprion lecontei* (Fitch), and analyses the functions of their compound eyes, dorsal ocelli, and antennae.

The functions of the two types of eyes were investigated by painting them with aeroplane "dope". Since the eyes of this species are a dark colour, a base coat of red dope was used to ensure complete coverage. To prevent light-leakage, a coat of black dope was applied after the base coat had dried. The forewings were then removed to prevent the escape of specimens used in outdoor experiments. From others the antennae were also removed. Neither wing-clipping nor the removal of antennae appeared to have any effect upon the normal responses of the insects to light. Since preliminary experiments indicated that males and females react alike, the larger females were used throughout. Furthermore, the filiform antennae of the females presented less difficulty during eye-painting than the bipectinate antennae of the males.

Indoors, the light reactions of treated insects were tested with a single, six-watt panel lamp mounted one inch above the reaction platform. In some experiments, a "Trico" suction fan, operating at low speeds, was used to provide directional air movement. Outdoors, sun and wind directions were recorded on the reaction platform, and "Polaroid" sheets were used to test reactions to plane polarized light as reported earlier (1, 2).

Fig. 1A illustrates typical reactions in response to a six-watt panel lamp indoors when different sets of eyes were functioning. Orientation was strongly photopositive and accurate in females with both types of eyes clear or with only the ocelli painted out. Although adults of *N. lecontei* with only their ocelli clear were much more active than *Sarcophaga* (2) indoors, they exhibited no orientation to the light source and often paused in their movements for long intervals, moving again only when prodded or otherwise disturbed.

Fig. 1B illustrates outdoor reactions of similarly treated adults. Again, insects with both types of eyes clear, or only the ocelli painted out, performed precisely orientated movements. In contrast to indoor reactions, insects with only their ocelli clear demonstrated a fair degree of orientation when tested outdoors. It has been shown (1) that body temperature controls to a large degree the angle of an insect's orientation to the sun. When cool, it orientates towards the sun. As it is heated, it may move at other angles in relation to the sun, until finally, when photic reversal levels are reached, the animal moves directly away from it. A broad range of temperature conditions were experienced over the period in which the tracks illustrated in Fig. 1B were recorded. Hence, insects are shown moving towards, at angles to, or away from the sun. The accuracy of orientation of insects with only their ocelli clear depended on body temperature. When cool, they reacted much like they had indoors, exhibiting little orientation. However, as temperatures increased, their paths straightened out and finally became strongly negative at high temperatures. At

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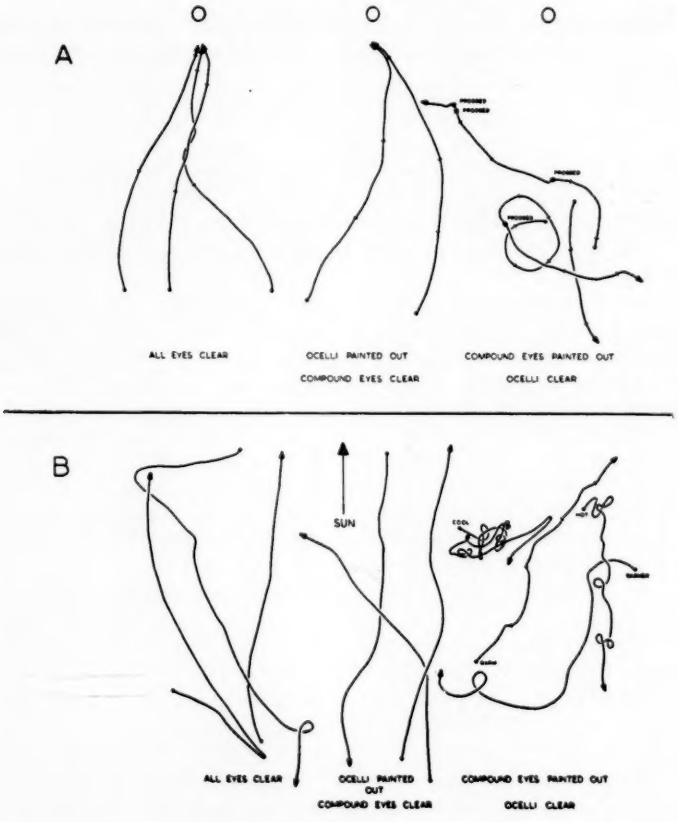

Fig. 1. Responses of adults of *N. lecontei* to light indoors and outdoors. A: tracks recorded in a darkened room with a six-watt lamp in the position shown. B: recorded tracks of similarly treated insects outdoors. Time-marks, where they appear, indicate ten-second intervals.

moderate or high temperatures, insects with only their ocelli clear became disorientated if the sun and the overhead sky were obscured by cloud, but moved directly if the sun or the overhead sky were clear. Precision of orientation was never as great as in insects with both types of eyes clear or with only the ocelli painted out, but was nevertheless effective in directing their movements at moderate and high temperatures.

Fig. 2 illustrates sample paths followed by blinded insects with intact antennae, and with these structures removed. Fig. 2A demonstrates differences in indoor responses of blinded insects with intact antennae in still air, and when a directed flow of air was passed over them. Blinded insects failed to orientate to the six-watt panel lamp. Under conditions of still air indoors, their paths were quite disorientated, but, when a directed flow of air was passed over them, they moved in relatively straight lines. They seemed to exhibit no definite angle of orientation to the direction of air flow, but instead, headed in the direction they were facing when placed on the reaction platform. Under these conditions,

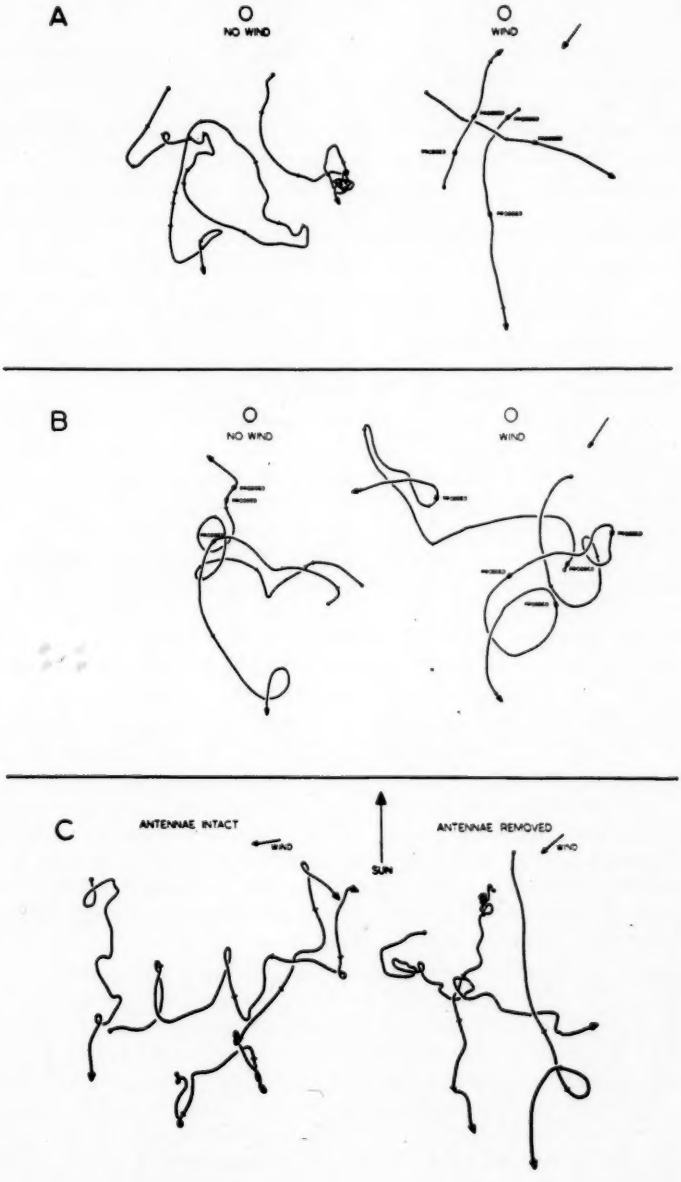

Fig. 2. Responses of blind adults of *N. lecontei* to light indoors and outside. A: indoor responses of blind insects with intact antennae. B: indoor responses of the same insects with antennae removed. C: outdoor responses of blind insects with intact antennae and with these structures removed. Wind directions are shown by small arrows. Time marks, where they appear, indicate ten-second intervals.

they often stopped in their travels for long intervals, moving again only when prodded.

Paths followed by the same insects with their antennae removed are illustrated in Fig. 2B. Under these conditions, no straightening of the paths occurred even when a directed flow of air was passed over them. Clearly, the antennae of females of this species function as sensory receptors of air movment and enable the insects to maintain a straighter path in relation to it.

Outdoors (Fig. 2C) blind insects with intact antennae followed rather convoluted paths at moderate temperatures. These paths tended to straighten when the wind blew constantly from one direction during their travels. As temperatures rose to reversal levels, these insects moved away from the sun but by rather circuitous paths. The same insects, with their antennae removed, behaved in much the same way at moderate temperatures, but were more efficient in moving directly away from the sun at high temperatures. Wind blowing constantly from one direction had little effect upon their orientation. At first glance, it may seem that the relatively straighter paths followed away from the sun by blind, antenna-less insects is not in accord with the points brought out in Figs. 2A and 2B. However, it must be remembered that outdoors, and especially at ground level, wind is seldom undirectional. Furthermore, since blind insects cannot be orientating to the sun as a light source, they appear to orientate to it as a source of radiant heat at these higher temperatures. Under such conditions, antennal stimulation by intermittent winds blowing from different directions, might conceivably have confused the insect, this confusion having resulted in rather convoluted paths away from the sun. On the other hand, with antennae removed, wind had less effect on their orientation and the insects proceeded directly in response to insolation and body temperature. It is interesting to note that blind antenna-less insects moved away from the sun at high temperatures by straighter paths than did insects in which only the compound eyes were painted out (the ocelli and antennae left intact: Figs. 1B and 2C).

The reactions of adults of *N. lecontei* to plane polarized light were tested. Polaroid reactions in this species were very difficult to obtain and were recorded only on relatively clear days. It has already been shown (1) that smoke, haze, and ice-crystal cloud seriously affect the reactions of some insects to the polarization pattern of the sky. With this in mind, only days of minimal turbidity were chosen as experimental periods. Even with this precaution, the types of records obtained were quite variable (Fig. 3).

Tracks A to F show paths followed by insects with all their eyes clear. Tracks A and B show no reaction whatever to rotation of the polaroid axis. This lack of response was fairly common throughout the series of tests. Tracks C and D are examples of normal responses to rotation of the Polaroid axis, a 90° rotation of the axis producing a 90° shift in the track. Under ideal conditions, these are the most frequent reactions observed. Tracks E and F, on the other hand, illustrate abnormal responses. Track E records turns of almost 180° in response to a 90° setting of the Polaroid axis, whereas track F show turns of only about 45°. Of the two, 180° turns were the more common.

Tracks A to F were all recorded within a 40-minute period (1000-1040 hrs. E.S.T.) on an apparently clear day, and illustrate the variability that may sometimes occur in the reactions of a single insect or of members of a group. During this period, a Polaroid axis set parallel to the direction of the sun most often produced the expected response, but, on occasion, a crossed axis produced

results. This particular day was very clear but small patches of cumulus cloud were forming on the horizon, and it is possible that active, "dry" thermals overhead were influencing the polarization pattern.

Polaroid reactions performed by females with only the ocelli functioning are represented by tracks G to I in Fig. 3. Track G shows the track of an individual without the Polaroid sheet over it. The response when a patch of

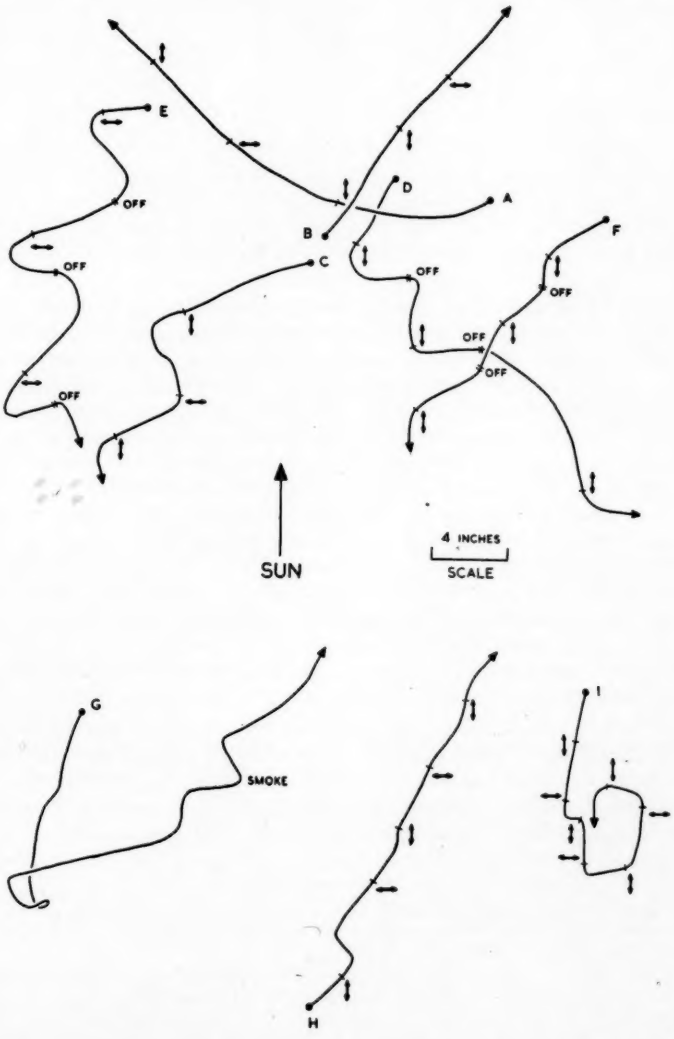

Fig. 3. Effects of rotation of the axis of a sheet of Polaroid held over adults of *N. lecontei* as they were crawling over the ground. Arrows beside the tracks show the orientation of the Polaroid axis with respect to the sun and the checks on the tracks indicate the points at which the Polaroid was placed over an insect or rotated. Tracks A—F: movements of adults with both types of eyes clear. Tracks G—I: movements of adults with only the ocelli clear.

smoke passed overhead is typical. Track H records: (a) the normal, 90° shift when the Polaroid was placed over the insect; (b) a return to the original path with the Polaroid still in position, and (c), on repeated rotations of the Polaroid, only very slight shifts in the track. No explanation, other than the possibility of active, "dry" thermals overhead, is offered for the return to the original direction or for the very slight shifts in the track, since the overhead sky appeared to remain constant throughout the travel. Track I shows, initially, a series of normal reactions to rotation of the Polaroid axis. However, at the fifth Polaroid setting, instead of making a 90° turn to the right, the animal turned to the left and proceeded on a course 180° to the expected. After this, successive rotations of the Polaroid axis produced further 90° shifts in the track, but the turns continued to be to the left.

If a response is obtained by rotating the Polaroid axis, an insect may respond by turning in either of two diametrically opposed directions. Both of these directions should give comparable patterns on the polarization analysers, so that, although an insect generally turns in the direction of rotation of the Polaroid axis, there seems to be no obvious reason why it should not also turn against the rotation of the axis.

Although no Polaroid experiments were performed using adults of *N. lecontei* with only their compound eyes left unpainted, it is surmised that reactions could have been obtained, since insects with all their eyes clear demonstrated more consistent Polaroid reactions than did insects with only the ocelli clear. Therefore, it is concluded that adults of *N. lecontei* with both or with only one type of eye functioning orientate to the polarization pattern of the overhead sky, and that the paths they follow may also be influenced by body temperature and stimulation of the antennae by wind. Outdoor tests with blinded adults indicate that they respond to the sun as a source of radiant heat, at least when body temperature is raised to reversal levels and this has also been shown by Wellington (unpublished) to occur in several other kinds of insects. It is becoming increasingly clear that even insects with all their eyes clear may utilize this same stimulation as their basic orientation-mechanism at high temperatures. Thus, at high temperatures, the responses of some insects to directed radiation may reduce, or even nullify, their usual response to sudden shifts in the polarization pattern of the overhead sky.

The need for quantitative analysis of the factors affecting insect orientation to outdoor light conditions is plain. However, pending the development of sufficiently sensitive instruments to record changing sky conditions, the task remains difficult, for it is impossible for even a practiced observer to be sure that any two days are strictly comparable.

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Paper Partition Chromatography in Entomological Research[1]

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Paper partition chromatography is a physico-chemical technique that enables the investigator to separate inorganic and organic constituents of various kinds, e.g., amino acids, purines, pyrimidines and related substances, sugars and their derivatives, organic acids, vitamins, antibiotics, and chemical elements, and measure them quantitatively.

This paper may serve as a guide for the entomologist in such a technique and suggests some of the more recent and useful sources of information. Examples of the results that can be achieved in certain fields of entomological investigation are given rather than a micro-technique already well worked out; standard procedure and the necessary equipment are discussed so that the uninitiated may carry on further with the help of the literature cited.

Materials and Methods

Consden, Gordon, and Martin (1944) first described in full the method of paper chromatography. The authors stated, "The separation of substances on a chromatogram depends on their differences in partition coefficient between a mobile phase and water-saturated cellulose." The cellulose, in the form of a strip of filter paper, apparently plays the role of an inert support with little or no adsorption occurring on it. With sheets of paper, a two-dimensional separation can be effected. The final result is the separation of the constituents of the solution on the sheet of paper. As a modification of the original method, Williams and Kirby (1946) suggested the now well-known and simple technique of capillary ascent. Concerning amino acid analysis, Dent (1948) provided a map showing the positions of some 60 ninhydrin-reacting substances on phenol and collidine-lutidine two-dimensional chromatograms.

Beginning in 1948, many workers reported semi-quantitative and quantitative procedures based on paper chromatography. Block, LeStrange, and Zweig (1952) provided an excellent guide in a laboratory manual with a summary of procedures in both qualitative and quantitative chromatography and references to the literature.

The necessary equipment and materials in organizing a laboratory for paper chromatography may be summarized as follows:—

Laboratory Space.—It is essential that a laboratory space be provided with adequate ventilation and fairly constant temperature and humidity. A fume hood equipped with an electric ventilator is usually satisfactory. A temperature of about 76°F. and a relative humidity of about 80 per cent in the laboratory yield excellent chromatographic separations when the solvent mixtures mentioned below are used.

Chromatograph Chambers.—Several types of air-tight chromatograph chambers are available. A chamber well suited for chromatography by capillary ascent is a five-gallon earthenware jar fitted with a glass plate sealed with desiccator grease. The two-way rack tank described by Datta, Dent, and Harris (1950) is also very useful when a large number (15 to 25) of two-dimensional chromatograms are prepared simultaneously.

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Filter Paper.—Numerous types of filter paper are recommended by various authors and may be used for specific purposes. However, Whatman No. 1 filter paper is satisfactory in most cases. Small two-dimensional chromatograms can be prepared by cutting a large sheet of paper (46.5 cm. by 57 cm.) in two or four equal sheets. The sheets are folded into cylinders by stapling the ends together with an ordinary desk stapler. The cylinders stand vertically in the jars without any support.

Micropipettes.—Suitable micropipettes may be obtained from Microchemical Specialties Company, Berkeley, California. Series of 0.2 to 10 microliters in capacity are the most satisfactory. Micropipettes may also be blown in the laboratory from fine capillary tubing and calibrated with mercury. Not more than three to five microliters of the solution to be analysed should be applied to the paper at one time.

Solvents.—Many solvent mixtures are suggested, and Block *et al.* (1952) give directions for preparing most of them. The solvents most satisfactory with water are phenol, organic bases such as collidine and lutidine (Koppers Company Inc., Pittsburgh 19, Pa.), acetic acid and other organic acids, and *n*-butanol and other alcohols.

Good results have been obtained by the authors with the following solvent mixtures for separating amino acids and sugars.

Phenol-water: Phenol crystals (e.g., Mallinckrodt U.S.P. XIV) are melted at 45°C. A volume of 200 ml. of distilled water is measured in a graduate cylinder of one liter capacity and the liquefied phenol is added to the water up to the liter mark. Approximately 10 ml. of 0.3 per cent ammonium hydroxide per 100 ml. of the phenol mixture may be added to bring the pH to about neutrality.

Collidine-lutidine-water: 2,4,6-collidine, 400 ml.; 2,4-lutidine, 400 ml.; and water, 375 ml.

n-Butanol-acetic acid-water: *n*-butanol, 300 ml.; glacial acetic acid, 60 ml.; and water, 140 ml.

These mixtures should be used when freshly prepared. The amounts of water in them at room temperature do not cause them to separate into two or more phases upon standing. A quarter of an inch of solvent should be placed in the bottom of each chromatograph chamber.

Figs. 1 and 2 (Auclair and Maltais, 1952) illustrate two-dimensional chromatograms of amino acids separated with the above solvent mixtures; the unidentified compound No. 10 in Fig. 1 and No. 22 in Fig. 2 has since been identified as homoserine.

Colour Reagents and Other Means of Detection.—Several procedures for determining the substances separated on the chromatograms are available. Colour reagents such as ninhydrin may be used to detect amino acids. The preparation of various colour reagents for identifying specific substances is given by Block *et al.* (1952). Radiations on fluorescent substances, acid-base indicators, specific enzymes, radio-activity, and microbiological assays on antibiotics are some other means of detection and identification.

Equipment for Quantitative Procedures.—For the analysis of amino acids, Thompson *et al.* (1951) reported a method in which quantitative development is achieved by placing the ninhydrin-sprayed chromatograms in a special reaction cabinet containing carbon dioxide saturated with ethanol vapors at 60°C. for 30 minutes. The colour spots are eluted and the relative colour densities of the

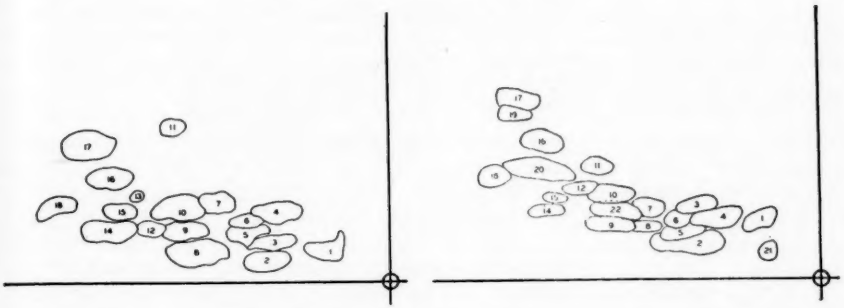

Fig. 1 (left). Tracing of a two-dimensional chromatogram of the amino compounds in pea-plant extract. Longest dimension in phenol-water; second dimension in collidine-lutidine-water. The numbers referring to individual amino compounds are as follows: 1, aspartic acid; 2, lysine; 3, glutamic acid; 4, serine; 5, asparagine; 6, glycine; 7, threonine; 8, arginine; 9, glutamine; 10, alanine and an unidentified compound; 11, tyrosine; 12, β-alanine; 13, *a*-amino-butyric acid; 14, methionine sulphoxide and γ-amino-butyric acid; 15, possibly β-amino-isobutyric acid; 16, valine; 17, leucine and/or isoleucine and phenylalanine; 18, proline.

Fig. 2 (right). Tracing of a two-dimensional chromatogram of the amino compounds in pea-plant extract. Longest dimension in phenol-water; second dimension in butanol-acetic acid-water. The numbers referring to individual amino compounds are as follows: 1, aspartic acid; 2, lysine; 3, glutamic acid; 4, serine; 5, asparagine; 6, glycine; 7, threonine; 8, arginine; 9, glutamine; 10, alanine; 11, tyrosine; 12, β-alanine; 14, methionine sulphoxide; 15, possibly β-amino-isobutyric acid 16, valine; 17, leucine and/or isoleucine; 18, proline; 19, phenylalanine; 20, γ-amino-butyric acid; 21, cystine; 22, an unidentified amino compound concealed by alanine in Fig. 1.

solutions are calculated from the readings on the Beckman spectro-photometer. Another procedure, described by Block *et al.* (1952), is based on the principle that the maximum colour density of each spot on a paper chromatogram is proportional to the concentration of the amino acid. The optical densities of the colour spots on the paper are determined by means of a photoelectric densitometer. The methods may be used to estimate amino acid quantity with an accuracy of three to ten per cent. With modifications, the two methods are applicable to the quantitative estimation of other substances.

Applications in Entomological Research

The method of paper chromatography can be applied best in studies on the physiology and biochemistry of insects. However, it has been used or can be used in other fields of entomological research such as toxicology, ecology, economic entomology, and taxonomy.

The method has been applied principally to analysis of amino compounds in insect blood. For example, Raper and Shaw (1948) described qualitative analyses of free amino acids in the haemolymph of nymphs of *Aeschna cyanea* Mull.; and Pratt (1950) reported results of qualitative analyses of free amino acids in the blood of seven species of insects and found differences between species.

Qualitative and semi-quantitative chromatographic estimations of organic constituents in insect blood, excretions, organs, and tissues have been made. Kodani (1948) reported on the composition of the protein in the salivary gland secretion in *Drosophila melanogaster* Mg. The secretions from the salivary glands of prepupae were extracted with ether and hydrolysed in boiling hydrochloric acid. Chromatographic analyses revealed the presence of some 16 amino

compounds. In a study of the nutritional influences on the intermediary metabolism in insects, Maltais and Auclair (1952) reported the occurrence of 22 free amino acids and amides in the honeydew excreted by the crescent-marked lily aphid, *Myzus circumflexus* (Buck.). Gray (1952) reported on the composition of the honeydew excreted by the pineapple mealybug, *Pseudococcus brevipes* (Ckll.). In both investigations, free amino compounds and carbohydrates were separated by paper chromatography. Organic acids were also detected by Gray (1952). By means of radio-active tracers, this author detected in the honeydew of the pineapple mealybug small amounts of constituents not easily identified by the usual tests. After pineapple leaves had photosynthesized in an atmosphere containing $C^{14}0_2$ for 24 hours, and when the mealybugs had fed on the radio-active leaves for 48 hours, the honeydew excreted was chromatographed and radio-autographed. The radiograms showed carbohydrates, amino acids, and organic acids containing some radio-active carbon.

Carter (1947) found that the ability of the mealybug to produce wilt in pineapples is governed by the nutrition of the insect. Auclair and Maltais (1950), in studies on the resistance of plants to aphids, demonstrated that a variety of pea susceptible to pea aphid attack contains a higher concentration of amino acids than a resistant variety. The amino acids separated from pea plant extracts are indicated in Figs. 1 and 2.

In insect toxicology, Moynihan and O'Colla (1951) separated isomers of chlorinated organic insecticides such as BHC. DDT was also readily separated from the BHC isomers and identified. Inorganic separations were also effected by several investigators (Block *et al.*, 1952).

The possible applications of the chromatographic method in taxonomy and ecology are exemplified by the work of Pratt (1950) on the blood of several insect species and that of Buzzati-Traverso and Rechnitzer (1953) on fresh tissue of several species of fish. The latter authors found wide differences between species in the organic constituents of tissues. Their preliminary results indicated further that paper partition chromatography can be used to distinguish stocks of the same species belonging to populations geographically separated. This could apply to other animal phyla, including Arthropoda.

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A New Species of *Catallagia* Rothschild from the Rocky Mountains of Alberta (Siphonaptera: Hystrichopsyllidae: Neopsyllinae)[1]

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The genus *Catallagia* Rothschild was considered to be strictly Nearctic until *C. dacenkoi* was described by Ioff in 1940 from the Altai Mountains of the U.S.S.R. In 1950, Skalon described two additional species, *C. ioffi* and *C. striatus*, from the Transbaikal and other areas of the U.S.S.R. All three of the Russian species are apparently parasitic upon mice, particularly of the genus *Clethrionomys* (=*Evotomys*).

The writer (1951) described a Nearctic subspecies of *Catallagia dacenkoi*, naming Fort Smith, Northwest Territories, as the type locality, where a number of specimens were collected from *Clethrionomys gapperi athabascae* (Preble), and listing collections from other areas in northern Canada, and Alaska. One specimen, a female from Atlin, B.C., was ascribed to this subspecies, agreeing well except for its abdominal spiracles, which were small by comparison with those of other specimens. In this connection, Skalon's description of the female of *Catallagia ioffi* is of interest, as he emphasizes that it is almost exactly similar to that of *dacenkoi* except for smaller spiracles; the males offer definitive characters in the genitalia. It seems reasonable to suppose, then, that a form closely related to *C. ioffi* occurs in the Atlin region.

Meanwhile, specimens of both sexes of a new species closely akin to *ioffi* have been found in the Rocky Mountains, about 65 miles north of Banff, Alberta. The single female from Atlin compares fairly well with this material, but a final decision on its identity should wait until males are found from that area.

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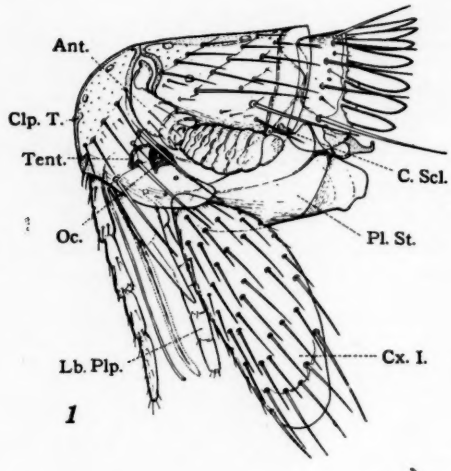
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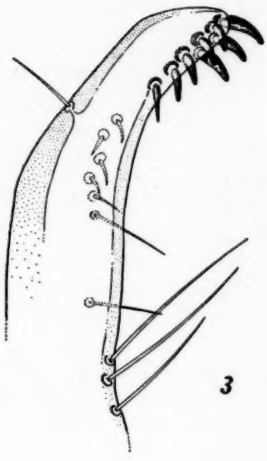

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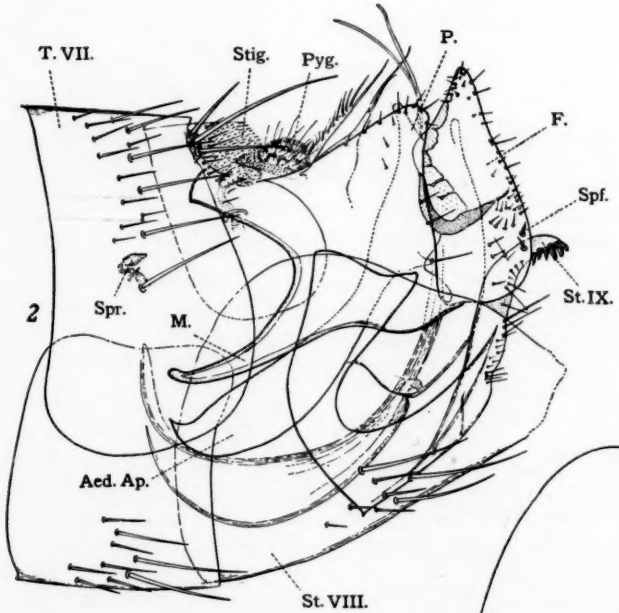
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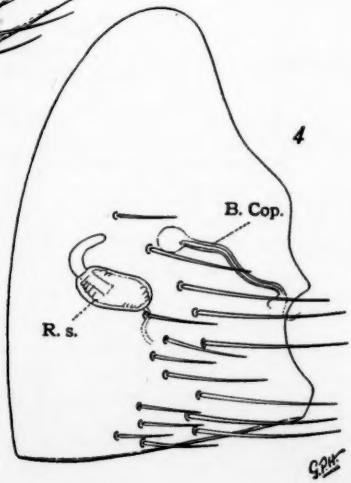
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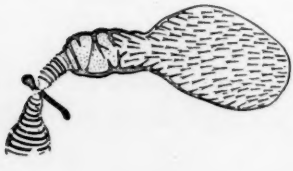

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***Catallagia jellisoni* new species**

Resembling *Catallagia ioffi* Skalon, a Palaearctic species, of which it might be considered a subspecies, although a decision on this point should await a comparison of specimens. Of the Nearctic species currently ascribed to *Catallagia*, most suggestive of *C. dacenkoi fulleri* Holland, particularly in the female, but easily distinguished by the abdominal spiracles, which are not greatly dilated as in that species (Figs. 6 and 7), and by the male genitalia. Except for the absence of a genal ctenidium, fairly readily assignable to *Epitedia* Jordan, thereby again raising the question (Holland, 1951) whether all the species lacking such a comb (i.e., *Catallagia*) constitute a natural assemblage, phylogenetically separable from *Epitedia.*

Male

Ocular setae four; the first seta long and set well in front of the eye, at the anterior margin of the antennal fossa; beside it a short seta. The remaining two setae of the ocular row long and, as in *C. dacenkoi*, inserted below the eye at a point somewhat more posteriorly than is usual in the genus (Fig. 1). Frontal row of about five subequal setae. Postantennal region with two oblique rows of setae in addition to the submarginal row. A small fronto-clypeal tubercle present. Eye slightly smaller than in *C. dacenkoi*, but fairly well pigmented. Labial palpus approximately two-thirds as long as the fore coxa, thereby apparently differing from *C. ioffi*, in which this organ is stated to be short, extending barely beyond the middle of the fore coxa (Skalon, 1950). Thin setae along the margin of antennal segment II, approximately one-quarter as long as the club. Cervical sclerite, or "first vinculum", extremely short, but articulating in a small sinus on the dorsal margin of the pleurosternal plate.

Pronotal comb of about 13 very heavy spines. Two dorsal, and one lateral, pseudosetae on each side, under the collar of the mesonotum; metanotum lacking these structures. Metepimere with eight or nine lateral setae.

Apical spinelets of abdominal terga as follows: I, 1 spine (or 0) per side; II, 2 spines (or 1); III, 1 spine; IV, 1 spine; V, 0 spines (or 1). Abdominal terga II-VII each with two rows of setae, the anterior row of about eight or nine short setae and the posterior row of about seven long setae, those of the posterior row alternating with fine intercalary hairs. Setae of anterior row not extending below the spiracles. Stigma cavity of tergum VIII large, though not so large as that of *C. dacenkoi.* Ostia of typical abdominal spiracles not unusually large (Figs. 6 and 7).

Hind coxa with a row of spiniform setae, and abdominal sternum II with a lateral "striarium". Tarsal segments V of fore- and mid-legs with four lateral pairs of plantar bristles and a basal submedian pair; hind tarsi with just the four lateral pairs.

Antepygidial setae three, of which the upper is about one-half and the lower three-fifths as long as the middle one. Tergum VIII small, armed laterally with a few thin setae, and overlapped ventrally by sternum VIII, which is broad and bears ventrolaterally about three strong, and five weak, setae. Apical margin of sternum VIII entire, lacking the conspicuous lobes found in *C. charlottensis* and its near relatives, or even the broad, undulating lobes of *C. dacenkoi.*

Figs. 1-6. *Catallagia jellisoni* n. sp. 1, Head and prothorax of male (holotype). 2. Terminal abdominal segments of male (holotype). 3, Enlarged detail of apex of ventral arm of sternum IX of male. 4, Sternum VII and spermatheca of female (allotype). 5, Anal stylet of female. 6, Enlarged detail of 4th abdominal spiracle of female.

Fig. 7. *Catallagia dacenkoi fulleri* Holland; enlarged detail of 4th abdominal spiracle of female.

Clasper broad, and bearing a very large movable process which is acuminate dorsally and extends well beyond the apex of the fixed process (Fig. 2). Movable process obtusely angled just above the articulation and broadly rounded posteriorly. Articulating structures heavily sclerotized. Movable process beset laterally and marginally with numerous short, slender setae as shown and with two or three thicker, curved, almost spiniform setae inserted mesally near the posterior margin, much like those of *Epitedia faceta* (Rothschild). Fixed process simple, and bearing only a few small or medium setae on the apex or along the posterior margin; a longer seta below the acetabulum. Manubrium of clasper tapering to a blunt, turned-up point. Sternum IX very distinctive, the ventral (posterior) arm bearing about eight pigmented spiniforms. Of these, three large and arranged in a row on the ventro-apical margin; the remaining five somewhat smaller and forming a second row, overlapping the first, on the mesal apical surface (Fig. 3). Some additional slender setae disposed mesally and ventrally and one dorsally, as shown. Apex of sternum IX curved downward apically, though not so strongly as in *C. ioffi*, in the description of which it is likened to a paw.

Female

Details of chaetotaxy essentially similar to those of the male.

Second antennal segment with marginal setae about three-quarters as long as the club.

Anal stylet about five times as long as broad; a long apical seta, with two minute hairs at its base, and sometimes an additional seta, placed dorsally (Fig. 5). Sternum VII with an obtusely pointed lobe, with a shallow sinus dorsally and a deeper one ventrally (Fig. 4). About 18 setae per side on sternum VII, about eight being long and heavy. Tergum VIII with about three lateral, and about eight ventrolateral and submarginal, setae as well as a few shorter setae placed mesally, near the apex. Sternum VIII conspicuous, terminating apically in a long point. Bursa copulatrix with conspicuous sclerotic thickenings. Spermatheca larger than that of *C. dacenkoi*, with the head proportionately longer and the tail projecting deeply into the head of this organ. Three antepygidial setae as in the male, but the first and third proportionately somewhat longer.

Holotype.— ♂, Peyto Lake Trail, 6500-7000′, just below the vantage point at Bow Summit, Banff National Park, Alberta, 10.X.53, collected from *Clethrionomys gapperi* ssp., by G. P. Holland and O. Peck; No. 6131 in the Canadian National Collection of Insects, Ottawa.

Allotype.— ♀, same data.

Paratypes.—1 ♂, 1 ♀; same data.

The species is named after Dr. William L. Jellison, parasitologist, United States Public Health Service, Rocky Mountain Laboratory, Hamilton, Montana, in tribute to his achievements in parasitology.

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